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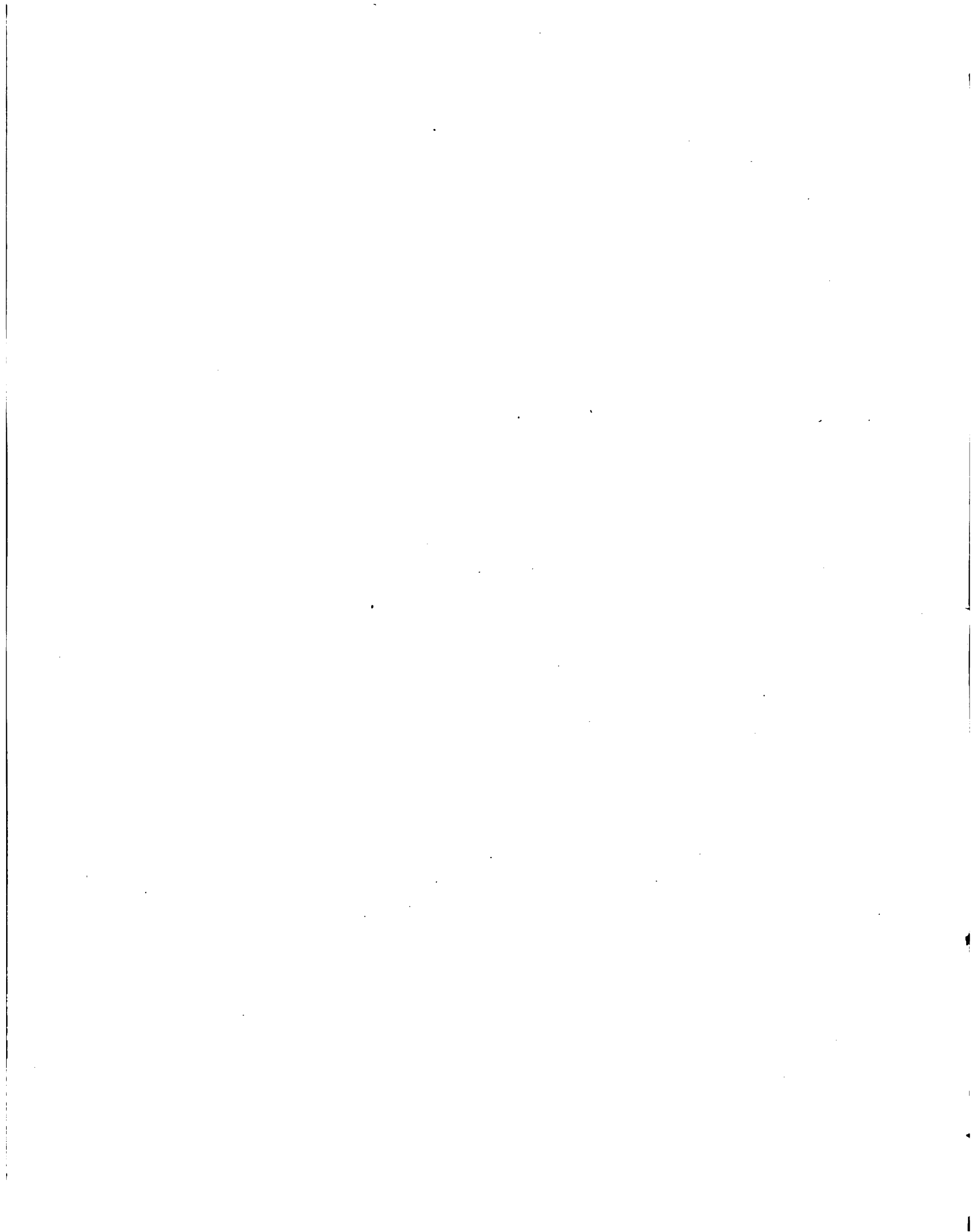
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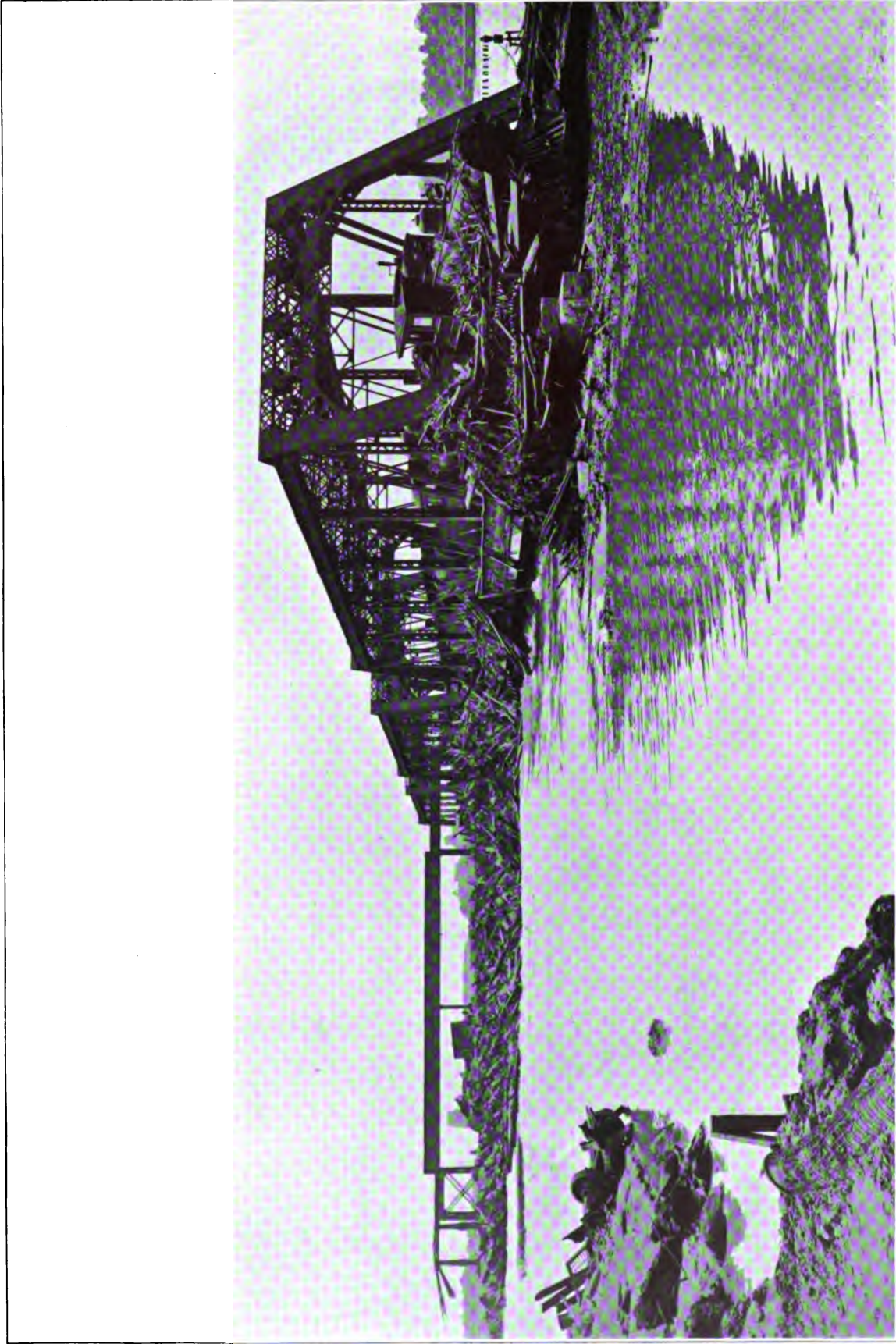
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The Missouri Pacific Railroad bridge over the Kansas River at Kansas City, Mo., after the water had fallen 8 feet. This bridge was the only one of 17 that was not carried away by the flood waters.

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U. S. DEPARTMENT OF AGRICULTURE,

U. S. WEATHER BUREAU.

Bulletin M.

THE FLOODS OF THE SPRING OF 1903, IN THE
MISSISSIPPI WATERSHED. *125481*

BY

H. C. FRANKENFIELD,

DISTRICT FORECASTER, IN CHARGE OF RIVER AND FLOOD SERVICE.

Prepared under direction of WILLIS L. MOORE, Chief U. S. Weather Bureau.



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE, WEATHER BUREAU,
Washington, D. C., July 28, 1903.

*The Honorable,
The Secretary of Agriculture.*

SIR: I have the honor to transmit herewith a report on the spring floods of 1903, in the Ohio, Mississippi, and lower Missouri valleys. This report has been prepared by Dr. H. C. Frankenfield, District Forecaster, and gives a history of the floods, together with such maps, charts, and photographs as appertain to the same.

I recommend the publication of this report as a bulletin of the Weather Bureau.

Very respectfully, your obedient servant,

WILLIS L. MOORE,
Chief U. S. Weather Bureau.

Approved:
JAMES WILSON,
Secretary.

THE LOWER MISSISSIPPI FLOODS.

General description.—The floods of March and April, 1903, in the Ohio and lower Mississippi rivers were especially noteworthy for the unprecedentedly high stages that occurred over the latter. From Memphis to the Passes the stages of the water were greater than ever before known, except in a few localities. The excesses over the highest previous stages, principally those of 1897, ranged from 0.9 foot at New Orleans to 2.8 feet at Memphis. At Helena the crest stage was 0.8 foot below the maximum stage of 1897, the deficiency being due to the crevasses in the St. Francis levee above Memphis. The escaping water through these crevasses reentered the Mississippi River by way of White River, the mouth of which is 87 miles below Helena, and, as a natural consequence, the flood crest at Helena was correspondingly depressed. For the same reason the crest at Memphis was lowered, although the maximum stage, notwithstanding the loss of the crevasse water, was 3.1 feet above the high-water stage of 1897 and 2.8 feet above that of 1898. From Helena to Vicksburg the flood plane was materially lowered by crevasses, both above and below, but not to an extent sufficient to prevent the highest stages of water ever known, except at Vicksburg, where the highest reading on the gage was 0.5 foot lower than in 1897. This deficiency would in all probability have been transformed into an excess had the Yazoo River been as high as it was in 1897, when the crest stage at Yazoo City was 31.5 feet, whereas in 1903 the highest stage was but 28.7 feet, 2.8 feet lower than in 1897.

It is the purpose of this introductory chapter to discuss, as briefly as possible, the causes of this flood and the effect of artificial conditions thereon; also to describe, in general terms, its extent, duration, consequences, and the work of the Weather Bureau in connection therewith. Frequent references will be made to the great floods of 1882 and 1897 in the same district, the only ones of the many that have preceded the flood of 1903 in which the conditions were approximately similar, as well as the only ones for almost two generations with which it is best comparable in point of volume.

Basin of the Mississippi River.—It is presumed that the extent and character of the great basin of the Mississippi River is more or less familiar to all. A diagram of the same will be found on Chart I. Those whose recollections or impressions are in any manner indistinct are referred to Prof. Park Morrill's work on Floods of the Mississippi River, Bulletin E, Weather Bureau, 1897, in which may be found a very comprehensive description of the Mississippi and its tributary basins. The following table, taken from this work, will show at a glance their extent and comparative area:

THE FLOODS OF THE SPRING OF 1903.

TABLE I.—Grand divisions of the Mississippi basin.

Designation.	Area in square miles.	Ratio to whole basin.
Ohio basin.....	201,700	0.16
Upper Mississippi basin.....	165,900	0.13
Missouri basin.....	527,150	0.43
Arkansas basin.....	186,300	0.15
Red basin.....	90,000	0.07
Central Valley.....	69,000	0.06
Total.....	1,240,050	1.00

Causes of the flood.—The flood of 1903 owed its inception to a series of heavy rain-falls during the month of February that were caused by a succession of storms of the southwestern type, the best rain-producing type that this section of the country affords. The normal rains of February are usually sufficient to bring the lower Mississippi almost to the danger line, but during this month the amount of excess precipitation ranged from 1 to nearly 7 inches, the maximum fall occurring south of the Arkansas-Louisiana line (see Chart XI). As a natural consequence the river passed the danger line at all points, beginning at Arkansas City, on February 20, and at Memphis and Helena, on February 22. But while this rise was progressing the general rains from the same southwestern storms had extended into the Ohio watershed in practically undiminished quantities, particularly within the State of Kentucky, and stages close to, and in some places considerably above, the danger line were maintained throughout the month. The flood precedents of the past thirty years were thus closely observed, it being the usual rule for the lower Mississippi to rise to the danger line and then to receive the later flood wave from the Ohio. Should the Ohio not respond at these times, the lower waters would pass out into the Gulf of Mexico without untoward incident unless additional heavy rains should bring the Arkansas, Red, Ouachita, and Yazoo rivers to the flood stage. The great source of these floods, or at least their principal sustaining power, is the Ohio River with its swift-running mountain tributaries bringing down the snows of winter together with the heavy spring rains. Such was the condition of affairs during the closing days of February, although nothing had yet occurred to incite fears of serious consequences or of apprehension for the future. But the last day of the month and the first decade of March brought with them no change in the weather conditions. (See Chart XII.) The heavy rains persisted, and the rivers continued their slow yet none the less steady rise. It was then that the necessity for action was first suggested, and preparations begun for protective and preventive measures. The first flood warnings were issued at Pittsburg and Memphis on February 28, and the last at New Orleans on April 27, fifty-nine days after.

Duration of flood.—As the Mississippi, at New Madrid, had been at or above the danger line of 34 feet since February 17, the flood may be considered to have begun at that time, while May 21 may be taken as the last day, the river at New Orleans falling below the danger line of 16 feet at that time. This would make the total duration of the flood ninety-four days. In the Atchafalaya River it really continued until the end of May, the danger line at Melville not having been reached in the decline until May 31. The following table shows the number of days the various rivers were above the danger lines at different stations during the flood, and also those of 1897 and 1882:

Number of days the rivers were at or above the danger line.

Stations.	Danger line.	At or above danger line.			One foot or more above danger line.			Three feet or more above danger line.			Five feet or more above danger line.			Seven feet or more above danger line.			Nine feet or more above danger line.		
		1903.	1897.	1882.	1903.	1897.	1882.	1903.	1897.	1882.	1903.	1897.	1882.	1903.	1897.	1882.	1903.	1897.	1882.
Pittsburg, Pa.	22	3	2	0	3	2	0	2	1	0	1	1	0	0	0	0	0	0	0
Cincinnati, Ohio	50	6	7	9	4	6	8	1	6	5	0	6	3	0	4	1	0	4	0
Louisville, Ky.	28	1	7	8	0	6	7	0	6	6	0	4	4	0	2	3	0	0	1
Evansville, Ind.	35	45	33	60	40	32	54	30	28	41	17	24	20	3	6	11	0	0	6
Cairo, Ill.	45	25	48	56	18	47	49	14	41	15	8	19	9	0	0	0	0	0	0
St. Louis, Mo.	30	0	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Johnsonville, Tenn.	21	58	48	77	53	47	74	44	44	68	35	38	59	24	34	46	11	30	35
New Madrid, Mo.	34	53	54	.....	27	50	.....	16	43	.....	8	19	.....	0	0	.....	0	0	.....
Memphis, Tenn.	33	54	53	65	40	50	50	20	29	0	13	0	0	2	0	0	0	0	0
Helena, Ark.	42	67	61	79	58	58	72	29	48	48	22	35	5	15	17	0	3	4	0
Arkansas City, Ark.	42	82	72	84	78	69	73	71	60	34	42	50	1	31	33	0	20	6	0
Greenville, Miss.	42	39	45	.....	33	37	.....	22	8	.....	12	0	.....	1	0	.....	0	0	.....
Vicksburg, Miss.	45	60	70	.....	50	67	29	35	56	.....	21	37	0	0	0	0	0	0	0
New Orleans, La.	16	35	75	6	75	68	0	43	29	0	0	0	0	0	0	0	0	0	0
Newport, Ark.	26	7	8	.....	4	0	.....	0	0	.....	0	0	.....	0	0	.....	0	0	.....
Little Rock, Ark.	23	2	0	6	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Yazoo City, Miss.	25	47	71	.....	35	67	.....	20	52	.....	0	34	.....	0	0	.....	0	0	.....
Monroe, La.	40	38	0	.....	32	0	.....	16	0	.....	0	0	.....	0	0	.....	0	0	.....
Shreveport, La.	29	34	0	33	29	0	28	11	0	0	0	0	0	0	0	0	0	0	0
Alexandria, La.	33	33	0	33	31	0	28	7	0	0	0	0	0	0	0	0	0	0	0
Melville, La.	31	106	88	.....	98	81	.....	84	67	.....	62	9	.....	26	0	.....	0	0	.....

The river rose in one long and practically continuous swell from Cairo to the Gulf of Mexico, just as in 1897, except that during the latter flood the rise extended northward to the mouth of the Missouri River, whereas in 1903 there was no rise of consequence north of the mouth of the Ohio.

Conditions at Cairo, Ill.—At Cairo (see Hydrographs, Chart III) the rise began on January 28, the gage at that time reading 17.5 feet, passing the danger line of 45 feet on March 8, and continued for forty-seven days until March 15, when a stage of 50.6 feet was reached, 5.6 feet above the danger line. This stage was 1 foot below the high-water mark of 1897, and 1.2 feet below that of 1882. The river remained above the danger line until March 27. This high stage was the result of three distinct swells from the Ohio, of which the first began at Cincinnati on January 23, lasting until February 8; by February 15 the river had fallen nearly 20 feet to the 30-foot stage, and the second rise set in at about the same rate as the first, reaching its crest on February 20; there was a fall of nearly 25 feet within the week following, after which time the third and largest swell began, lasting until March 5, when a stage of 53.2 feet was recorded, 3.2 feet above the danger line. These tides from the upper river were supplemented by marked rises from the Wabash, Cumberland, Tennessee, and Green rivers, particularly the latter.

Conditions at Memphis, Tenn.—The water began to rise at Memphis on February 1, the gage then reading 10.8 feet; passed the danger line of 33 feet on the morning of February 22, and reached the crest stage of 40.1 feet, 7.1 feet above the danger line, on March 20. This stage was 4.9 feet above the high-water mark of 1882, 3.0 feet above that of 1897 and 2.8 feet above that of 1898. The river did not decline to the danger line until April 5.

Conditions at Vicksburg, Miss.—At Vicksburg the rise began on February 4, the gage on that day reading 21 feet, and continued steadily until March 27, passing the danger line of 45 feet on March 3. The maximum stage recorded was 51.8 feet, 6.8 feet above the danger line, and 0.5 foot below the previous high-water mark of April 16, 1897. The river fell below the danger line on May 1.

Conditions at New Orleans, La.—At New Orleans the rise began on February 8, with 9.1 feet of water on the gage. The danger line of 16 feet was reached on Feb-

ruary 26, and the crest stage of 20.4 feet on April 6. This stage was 0.9 foot higher than the previous high-water record of May 13, 1897. The water did not recede to the danger line until May 21.

Tributary effects.—As in 1897 the White and Arkansas rivers contributed but little to the flood waters, the latter hardly reaching the danger line. The Yazoo, while not as high as in 1897 by nearly 8 feet, was nevertheless above the danger line of 25 feet for forty-seven days during March and April and exercised some distinct effect upon the Vicksburg gage. The Red and Ouachita, however, which were at only moderate stages during 1897, had been abnormally high since the beginning of the year, and were from 3 to 4 feet above the danger line during March and a portion of April, 1903. These assisted materially in raising the flood crest below the mouth of Red River. The whole flood plane was also substantially elevated by the excessive precipitation of February and March over the lower watershed which completely filled the minor tributaries and the alluvial bottoms. An inspection of Charts XI and XII show that the precipitation during February ranged from 2 inches in excess of the normal amount above Cairo to from 4 to 9 inches in excess below that city. During March it was slightly deficient, except in Louisiana and southern Mississippi, where there was an excess ranging from 2 to 10 inches.

Comparison with previous floods.—In 1897, while the total amount of precipitation did not differ greatly from that of 1903, yet its distribution did. The excess above Cairo, from whence the major portion of the flood water was derived, was very nearly double that of 1903, while below the reverse was more than true. In 1882, when the flood volume was much larger than in either 1897 or 1903, there was an excess of precipitation above Cairo of 5 to 8 inches and of 7 to 11 inches below. Yet, notwithstanding these deficiencies of precipitation in 1903, particularly above Cairo, where the floods really had their inception, the stages below Cairo were higher than ever before, except in a few places, where local crevasses depressed the flood plane somewhat. At Memphis the excess was 4.9 feet above the high-water mark of 1882, as stated before, and 2.8 feet above that of 1897. This disparity between volume and stage can perhaps be more readily observed by an inspection of the table on page 5, which shows the number of days the rivers were above the danger lines. Thus in 1882 the Ohio River, which furnished most of the flood water and which is not leveed, was at or above the danger line of 50 feet at Cincinnati for nine days, with a maximum stage of 58.6 feet on February 21; in 1897 it was at or above the danger line for seven days, with a maximum stage of 61.1 feet on February 26; whereas in 1903 it was at or above the danger line but six days, with a maximum stage of only 53.2 feet on March 5. At Evansville in 1882 the river was at or above the danger line of 35 feet for sixty days, and for eleven days it was at or slightly over 42 feet; in 1897 it was at or above the danger line for thirty-three days and at 42 feet or more for six days; whereas in 1903 it was at or above the danger line for forty-five days and at 42 feet or more for three days. At Cairo in 1882 the river was at or above the danger line of 45 feet for fifty-six days and at or above 50 feet for nine days; in 1897 it was at or above the danger line for forty-eight days and at or above 50 feet for nineteen days; whereas in 1903 it was at or above the danger line only twenty-five days and at or above 50 feet for eight days. It will be seen that the normal relations between volume and stage obtained along the Ohio River, except at Evansville, where local tributary effect prolonged the

35 to 38-foot stage in 1903. The upper Mississippi contributed a fair quantity of water, the gage at St. Louis reading slightly above the danger line of 30 feet for five days in 1897 and a few feet below in 1882 and 1903. But below Cairo there was, so to speak, a decided reversal of form. While the river at Memphis was at or above the danger line of 33 feet in 1903 for only fifty-four days, as against sixty-five and fifty-three in 1882 and 1897, respectively, yet it remained at 38 feet or higher for thirteen days, and at 40 feet for two days, whereas in 1882 and 1897 the highest stages were 35.2 and 37.1 feet, respectively. At Helena and Vicksburg the figures are not fairly comparable, as the flood plane was depressed somewhat through the escape of crevasse waters above. But at New Orleans, where practically all of the water passed, the river was at or above the danger line of 16 feet in 1882 for only six days, with a maximum stage of 16.2 feet; in 1897 it was at or above the danger line for seventy-five days, and at 19 feet or more for twenty-nine days, with a maximum stage of 19.5 feet; whereas in 1903 it was at or above the danger line for eighty-five days, and at or above 19 feet for forty-three days, with a maximum stage of 20.4 feet. It is evident, therefore, that the absence of the natural sympathetic relations between volume and stage in these latter floods in the lower Mississippi River must be attributed to some extraneous cause, and that cause is apparently the restraining influence of the levees which have been steadily building for many years, especially during the past twenty, and still more especially during the past ten years.

Effects of levees, and extent of overflow.—Since 1897 the St. Francis system of levees has been extended until it now reaches from Point Pleasant to the head of Cat Island, a distance of 173 miles, and an increase during the past six years of about 48 miles. The entire line has also been raised about 2 feet with a corresponding increase in the width of the base.

Previous to 1897 the area of the St. Francis bottoms subject to overflow in time of flood was something over 6,000 square miles. In 1897, after the levee had been built from Point Pleasant to Pecan Point, an actual distance of 125 miles, the area overflowed had been reduced to about 2,700 square miles. In 1903, after the extension of the levee to the head of Cat Island, the submerged area was still further reduced to approximately 1,800 square miles, a reduction of over 4,000 square miles in twenty years, and of about 900 square miles in six years. (See Chart II.)

The results are easily apparent. The immense volume of normal overflow water, prevented by this great artificial barrier from finding its natural outlets, was confined to the immediate channel of the river, and the direct consequence was an abnormal increase in the height of the flood crest without the usual increase in the initial volume as indicated on the Cairo gage. Had not the crevasses occurred at Random Shot and Hollybush, it is very probable, as the official in charge of the Weather Bureau office at Memphis states, that the difference in the gage readings at Cairo and Memphis would have been but 9 feet instead of 14.5 and 16.8 feet in 1897 and 1882, respectively. This assumption must be qualified, however, by the admission that the railroad embankment forming the Arkansas approach to the Memphis Bridge, which is a short distance below the city, probably exercised some effect by ponding the flood waters, and throwing back a portion of it upon the Memphis gage.

Below Helena the same general conditions obtained. Since 1897 only about 50 miles of new levees were constructed, and those in the New Orleans district, principally

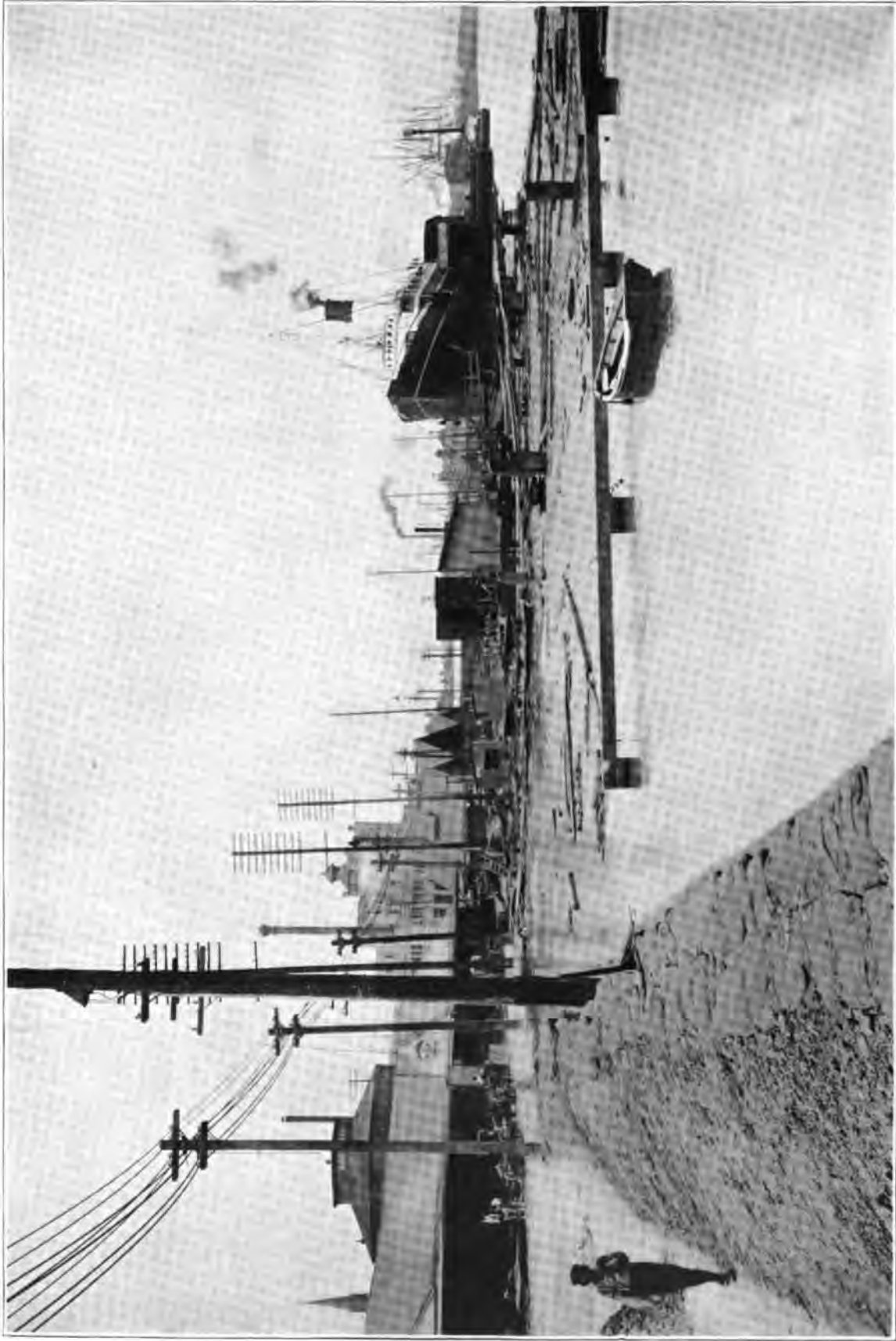
along the left bank between Fort St. Philip and Venice, in the extreme southeastern portion of Plaquemines Parish. All levees, however, have been improved, both as to height and body; crevasses were fewer and less disastrous, and, as a consequence, the stages were generally higher than ever before, except in a few localities where the loss of water through crevasses slightly lowered the flood plane.

The overflowed territory in the Yazoo basin comprised but 1,460 square miles in 1903, about 2,600 square miles less than in 1897, and about 5,200 square miles less than the greatest area subject to overflow previous to that time. On the right bank of the river, from Helena to Vicksburg, 960 square miles of land were overflowed, over 3,000 square miles less than in 1897, and over 5,000 square miles less than the greatest area subject to overflow previous to that time. From Vicksburg to the mouth of the river, and on the left bank, approximately 250 square miles of the country were submerged, whereas in 1897 only about 25 square miles were flooded. The greatest area subject to overflow previous to 1897 was about 2,400 square miles. Along the right bank the overflowed area comprised perhaps 1,700 square miles, including that affected by bayous and interior rivers. This was about the same as in 1897, though differently distributed. The greatest area subject to overflow previous to that time was about 8,000 square miles.

The following table shows in concise form the extent of the overflowed areas for the different districts and periods:

District.	Time.		
	1903.	1897.	Previous to 1897.
	<i>Square miles.</i>	<i>Square miles.</i>	<i>Square miles.</i>
On the left bank:			
Commerce to Memphis	650	583	616
Yazoo bottoms	1,460	4,273	6,648
Vicksburg to mouth	250	25	2,400
On the right bank:			
St. Francis bottoms	1,800	2,660	6,090
Helena to Vicksburg	960	4,265	6,107
Vicksburg to mouth, including bayou districts ..	1,700	1,774	8,109
Total	6,820	13,580	29,970

Profit and loss.—It is impossible to even approximately estimate the losses resulting from this flood, or the value of the property saved as a result of the warnings of the Weather Bureau. It is a truth, however, that the losses were comparatively insignificant when contrasted with the vast amount of property saved. Along the Ohio River, below Louisville, the value of winter wheat destroyed, together with the losses occasioned in various other ways, amounted to perhaps \$150,000, while the approximate value of property saved, as indicated from reports received, was about \$1,500,000, of which over \$500,000 was saved in the vicinity of Paducah alone. Below Cairo the damage was really inconsequential as compared with the value of the property saved. There were, of course, many of the usual inconveniences and unpleasant features attendant upon great floods, such as the flow of the waters over plantation lands, and at times over cities and towns; the destruction of fences and levees; the interruption of railroad communication, etc.; but there was no loss of human life, no



New Orleans, La. Cromwell wharf, foot of Toulouse street.

drowning of stock, and no destruction of crops, although truck farmers along the extreme lower river suffered severely. Everything portable had been moved to places of safety, and the flood came so early that the crops had not yet been planted. As a matter of fact, the history of previous floods was repeated, and, aside from the temporary inconvenience suffered, the overflow was a positive benefit to the plantation lands, as they were enriched with a fine new deposit of alluvion, left by the receding waters. In some few instances, however, heavy deposits of sand almost ruined the lands.

It is probable that the most expensive features of the flood were the cost of strengthening the levees, refilling crevasses, and repairs to the railroads. The latter, however, was not a very serious one.

As before intimated, the total value of the property saved by removal or protection is a matter of conjecture only. During the flood of 1897 the value of property moved to places of safety as a result of the Weather Bureau warnings was approximately \$15,000,000, personal property not considered. The value of that moved in 1903 was not less, and was doubtless much greater, as the wealth of the various communities affected has increased considerably during the past six years.

Work of the Weather Bureau.—From many sources of information, including press reports, it is apparent that the Weather Bureau has not only maintained the high character of its river work, but has done even more by establishing a new standard of accuracy, one of almost absolute exactness. Although the forecasts and warnings were in some instances issued three and four weeks in advance, there was no repetition of the criticism of 1897 that "the Weather Bureau was needlessly alarming the people in the threatened districts." Previous experience had established confidence, and when the warnings were received they were heeded without question and without delay. The exactness with which the time and height of the flood crests were forecasted brought universal commendation and saved a vast amount of unnecessary labor. The following table shows the stages forecasted and those actually reached at various places from Cairo to New Orleans. The forecast at the former place was made four days in advance, and that at the latter twenty-eight days in advance of the flood crest.

Stations.	Forecast stage, feet.	Actual stage, feet.
Cairo.....	50.5 to 51.0.....	50.6
Memphis.....	40.0	40.1
Helena.....	51.0	51.0
Arkansas City.....	53.0	53.0
Greenville.....	49.0	49.1
Vicksburg.....	52.0	51.8
New Orleans.....	21.0	20.4 to 20.7

A large number of letters and press notices commendatory of the work of the Weather Bureau, during this flood, have been received. The following extracts from an editorial article in the New Orleans Times-Democrat of April 12, 1903, will illustrate their general tenor:

"We have been placed this year under another obligation to the Weather Bureau for its high-water news and predictions. It has kept the people of the lower Mississippi well informed of what they may expect in the way of high water, and its predictions have been subsequently verified by the facts.

* * * * *

"Taking the present season as a sample, the warnings of the Weather Bureau have been so accurate as to give us great confidence in it. It has predicted within a

fraction of a foot the height the river would reach at various points, and been very close to the date of maximum high water; on this point the Bureau advised us that breaks in the levee system, by checking the discharge of the river, would delay the arrival of the wave crest of the high water."

In the pages immediately succeeding will be found the detailed reports of the flood prepared by the officials in charge of the regular Weather Bureau stations from Evansville to New Orleans.

Ohio River at Evansville, Ind., reported by Mr. Joseph L. Cline, Observer, Evansville, Ind.—The river passed the danger line of 35 feet at 12:15 p. m., March 3, and reached a maximum stage of 42.35 feet at 8 a. m., March 11; after this time it receded slowly, and fell below the danger line about 10 p. m., March 23. The bottom lands were overflowed from 1 to 2½ miles from the banks of the river. About 300,000 acres of corn land were submerged in this vicinity, but no damage of consequence resulted, as planting had not yet begun. About 25,000 acres of winter wheat were overflowed from March 6 to 22, the crops on more than 3,000 acres were totally destroyed. It is estimated that the damage to the wheat crop from the flood in this section will amount to more than \$50,000. Had not the water kept in constant motion the damage would have been decidedly greater.

The timely warnings issued by the Bureau enabled farmers to move live stock and other property to higher ground, consequently the only loss caused by the flood was that of the wheat above mentioned.

Ohio River from Louisville, Ky., to mouth, except in vicinity of Evansville, Ind.; Mississippi River from below St. Louis, Mo., to Cairo, Ill., by Mr. P. H. Smith, Observer, Cairo, Ill.—This flood had its beginning in the latter part of January, 1903, although the maximum stage was not reached at Cairo until March 15, 1903, and was the result of a series of rainstorms that occasioned rises which followed one another in such close succession as to cause a higher crest with each recurring tide.

The first rise gave Cairo a crest stage of 43.5 feet on February 17. The river remained stationary at 43.5 feet for two days, then gradually declined to 42.6 feet by February 21, when a second rise set in, which crested at 44.0 feet on February 27. After this rise the river fell for five days. A third rise commenced on March 4, with a crest of 50.6 feet on March 15. The river remained stationary at 50.6 feet for three days, commenced falling by the morning of March 18, passed below the danger line of 45 feet on March 27, and continued falling until the morning of April 9, when the gage read 36.0 feet.

Within the period covered by the rises noted above, six rises occurred in the Mississippi above Cairo, which added somewhat to the volume of water at the mouth of the Ohio. Moderate floods prevailed in the lower Wabash, Cumberland, and Tennessee during much of the time that the lower Ohio was in flood.

Timely warnings were issued as occasion required, and were of great value; every precaution necessary was taken to protect property and to reduce to a minimum the destructive effects of the flood. The bulletins issued by the Central Office and the warnings and general forecasts issued by the Cairo office, were widely disseminated by mail, telephone, and telegraph.

The maximum stage reported from Mount Vernon was 43.2 feet on March 13-14, 1903. Mr. Charles M. Spencer, of that city, makes the following report:

"Warnings and information furnished me were published in the daily papers, posted on the bulletin board, sent through the mails, and telephoned throughout the south and west parts of the county. Such action as getting stock to highlands and shipment of corn was taken to protect property; \$100,000 in property was protected and all saved. * * *."

At Shawneetown the maximum stage was 47 feet, on March 14-15. Mr. Charles Carroll, of Shawneetown, reports as follows:

"Information from the river reports received from you was posted here in a public place, given by phone to town and country places in this vicinity as far as could be reached by that method, by postal card, and otherwise—information was given promptly and in full.

"In the river bottoms and lands subject to overflow there were residents, stock, implements, and some crops. The warnings gave sufficient time for people to remove their families and property to places of safety, and consequently there was very little property lost. An estimate of the value of property protected and saved through this information can not be made. Throughout the area which profited by it there is a vast amount of property and the river dispatches received were, and always are, of untold value."

The maximum stage reached at Paducah was 47.6 feet, March 15-16, 1903. Mr. S. A. Fowler, General Freight Agent of the Evansville, Paducah, and Cairo Line, reports as follows:

"The information furnished me was published in the three daily papers and posted on the bulletin board in front of this office. Prompt and efficient action was taken to protect property threatened from overflow, and it is conservatively estimated that \$500,000 worth of property was removed from cellars and lowlands close by to high places, free from danger."

At Cairo, although the river came within 1.6 feet of the high-water mark and was above the danger line for nineteen days, no damage whatever resulted locally. The drainage pumps kept the waste water and seepage down to a desired level, and no inconvenience was experienced from this source.

All the bottom lands in the vicinity of Cairo were submerged, thousands of acres of wheat damaged, and much fencing destroyed. Many farmers are heavy losers from the overflow. Some state that the wheat crop will probably average from one-half to two-thirds crop, although it is impossible at this time to accurately estimate the extent of the damage. Some wheat has been entirely destroyed.

Ample warning was furnished the public, and it is believed that no loss occurred that could have been prevented by a warning. A few of the factories in this neighborhood were compelled to close for a short period.

At Birdspoint, across the Mississippi from Cairo, the St. Louis, Iron Mountain, and Southern Railroad was forced to suspend freight traffic from March 12 to 25, inclusive. About 600 or 700 feet of the roadbed were washed out. The Cotton Belt Railroad tracks were more or less submerged for a distance of 25 miles back from Birdspoint. This road was shut out from Cairo from March 12 to 23, inclusive.

About 300 feet of the roadbed of the Mobile and Ohio Railroad between Fort Jefferson and Wickliffe caved into the river when the flood was at about its crest.

Mississippi River from below Cairo to Helena, Ark., by Mr. S. C. Emery, Local Forecast Official, Memphis, Tenn.—Owing to the sudden influx of water from the Cum-

berland, Tennessee, Wabash, Forked Deer, Hatchie, and Wolf rivers, the three flood crests that moved down the Ohio during February and the early part of March, were, after reaching the Mississippi, merged into one long swell, which had its beginning on February 1, and continued well into April. The crest of the rise passed Cairo on March 17 with a stage of 50.6 feet. New Madrid, on March 18, at a 39.5-foot stage, Memphis, March 20, at 40.1 feet, and Helena, March 27, with 51.0 feet marked on the gage, or 0.4 above the Cairo maximum.

During the first fifteen days in February the river rose 20 feet over the entire district, but following that the rise was very gradual until March 11, when it began to show a marked increase, and by the 15th the water was coming up on the gage at the rate of over one foot every twenty-four hours. Considering the high stage of water, this rapid increase is remarkable, and probably unprecedented.

The breaking of the levee at Hollybush, on March 16, and at Random Shot two days later, whereby a great volume of water was diverted to the St. Francis bottoms, caused a sudden check in the rise at Memphis, and during the next five days the total increase only amounted to 1 foot, when the river came to a stand at 40.1 feet. Had no break occurred the rise would doubtless have been slightly prolonged and possibly another foot or two might have been added to the maximum stage at Memphis.

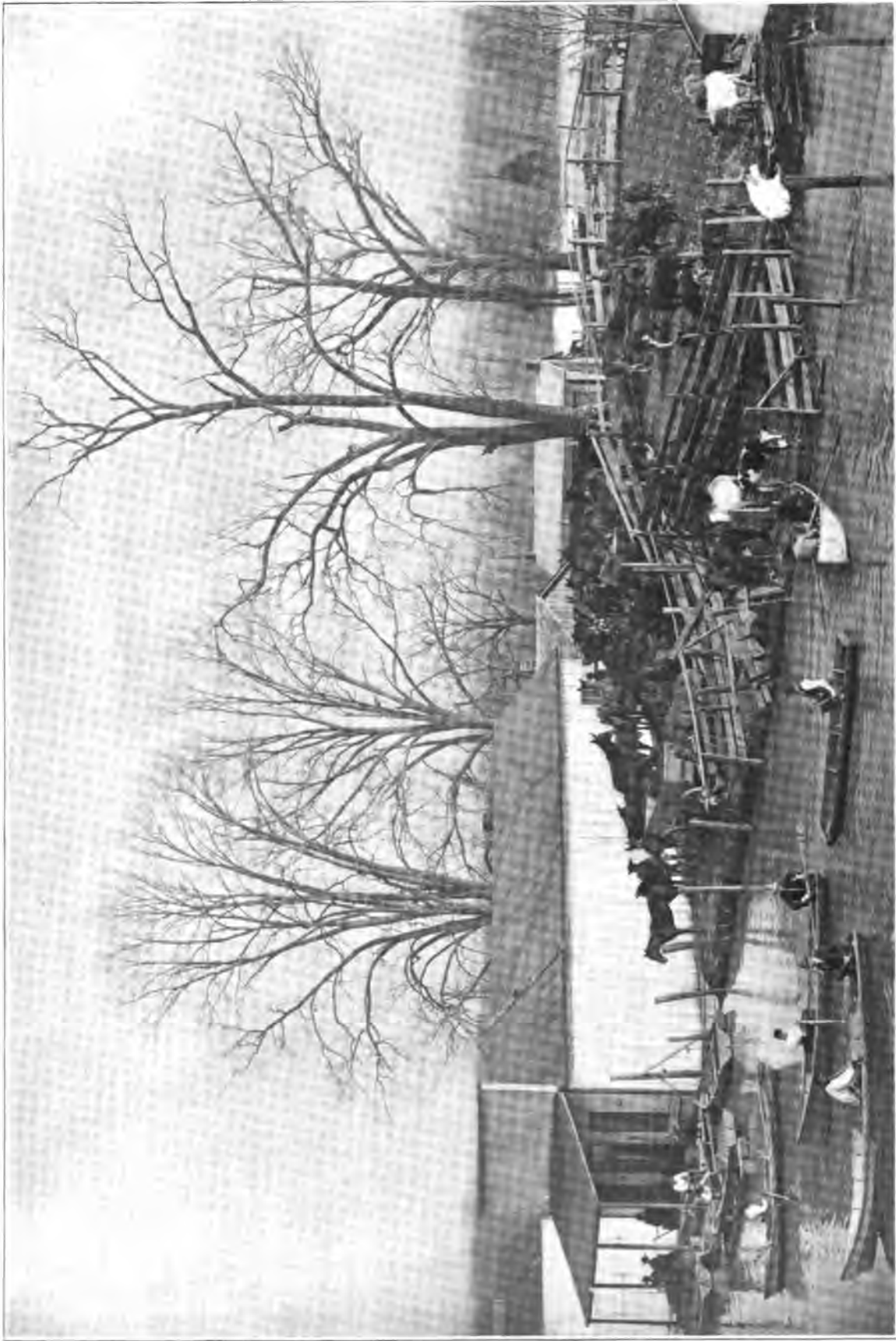
A second rise set in on April 13 that brought danger-line stages over the entire district as follows: Cairo, six days; New Madrid, eleven days; Memphis, eleven days; and Helena, sixteen days.

From the last week in January, which marks the beginning of this remarkable flood period, to March 1, a steady rise had been in progress over the entire length of the district. On the latter date the river from Cairo to Helena was from 2 to 3 feet above the danger line, and at various places the water was well up against the levee. Many of the lowlands at this time were under water, and the people were seeking safety on higher ground.

The heavy rains that prevailed over the upper valleys during the first week in March, together with the great volume of water then known to be moving down the Ohio River and its tributaries, began to excite serious alarm throughout this whole section. Warning bulletins were mailed to every post-office in the threatened district and the prediction was made that the river at Memphis would equal or exceed the highest known stage. Through the use of the mails, telegraph, telephone lines, the daily press, and by the cooperation of the various railroad companies every intelligent person in the district was made aware of the impending danger, and in ample time to make all necessary preparations.

By the liberal distribution of reports giving the daily river stages throughout the country, supplemented at frequent intervals by warning and advisory bulletins, all interests were thoroughly in touch with the Weather Bureau, and thus kept informed as to the situation from day to day. The work of the River and Flood Service in furnishing information regarding this flood was complete and satisfactory and was the means of saving both life and property.

Since 1897 the levees in this district have all been greatly strengthened and enlarged, so that the occupants of the territory thus protected felt practically secure and were loath to doubt the ability of the embankments to hold all of the water then in sight. These levees were constructed to hold a stage of between 38 and 39 feet on



Mississippi River. An Indian mound in Arkansas during the flood.

the Memphis gage, but on March 10 the river had reached 35 feet, with an additional rise of 4 feet predicted within ten days, which would bring the stage at Memphis to 39 feet and about 50 feet at Helena. This announcement caused a general movement of stock and other property to places of safety and a thorough patrolling of the levees by the Government engineers for protection against possible breaks and unlawful interference. At this time the old levee at Caruthersville began to show signs of crumbling, and it became necessary to commence the construction of a loop around the part affected. The building of this loop was a matter of very great importance to all residents in the St. Francis basin, and though the work was performed under great difficulties, on account of the wet condition of the soil and the constant rains, it was finally accomplished, but not before about 1,000 feet of the old levee had crumbled into the river.

On March 15 the crest of the wave had reached Cairo, and though the daily rise at New Madrid had dropped to one or two tenths of a foot, at Memphis and Helena the water was rising on the gage at the rate of over one foot every twenty-four hours. Warnings were then issued to the effect that a stage of 40 feet would be reached at Memphis before the water came to a stand. At this time the water was topping the levee at Hollybush, and the whole line from Point Pleasant to Cat Island, 25 miles below Memphis, was in a very dangerous condition. A force of over 1,000 men was employed, both day and night, and all means that engineering skill could devise were brought into use in the endeavor to save the country from the overflow that was sure to follow the giving away of the levee embankment. This fight against the flood was probably the most extensive and persistent ever attempted in the history of levee engineering, and, though all the help and material available were concentrated at the points of greatest weakness, it became apparent that a break was inevitable. On the morning of March 16, therefore, the work at Hollybush was abandoned, after which the embankment crumbled away for a distance of 5,000 or 6,000 feet.

The break occurred at the head of a wide ravine, which acted as an outlet for the water into Marion Lake, about five miles distant. From thence it spread southward, overflowing the tracks of three lines of railroads and completely inundated the town of Marion, the seat of Crittenden County. In several places the railway embankments were entirely washed away, and for a time the train service on all roads passing through the St. Francis basin was necessarily suspended. From Marion southward the water followed the general course of 15-Mile Bayou, causing the almost complete inundation of Lee County and the greater portion of the counties of Crittenden and St. Francis. The second break in the levee occurred March 18, at Random Shot, 2 miles above Pecan Point and 42 miles above Memphis. The effect of this break was to flood the southern portion of Mississippi County and complete the inundation of St. Francis County. After leaving the main stream through the Random Shot crevasse, a portion of the water moved in a northwesterly direction, through the Golden Lake bottoms and Frenchmans Bayou, to the Tryonza River. The remaining waters from the break passed through Swan and Wappenocca lakes, Big Creek, and the Tryonza, to the St. Francis, which carried them to the country below.

From St. Francis County southward the entire basin, except an occasional ridge of high ground, was more or less covered with water, and in many places the only means of communication was by small boats.

Compared with the overflow in the St. Francis basin in 1887, that of 1903 was

much less serious, both as regards the area affected and the depth of water over the basin, while the widespread distress and loss of property so notable in the former was almost entirely lacking in the latter. An exception should, however, be made in regard to the extreme eastern portion of the counties of St. Francis and Crittenden. In that section the water was the highest ever known and the damage to plantations, mill, and railroad property was very great.

The lowlands in the vicinity of Helena were badly flooded, but the city proper, being well protected by levees and occupying high ground, escaped any serious damage.

At New Madrid the water covered the south and west portions of the city to a depth ranging from 6 inches to $2\frac{1}{2}$ feet, but owing to the early recession of the flood no damage was done.

The submerged territory on the east, or Tennessee side of the river, embraced all of the bottom lands between Memphis and the Reelfoot Lake region, as well as the lands adjacent to the Obion and Forked Deer rivers, for 20 miles or more from their junction with the main stream. The flooded area on this side of the river exceeded, both in extent and severity, any previous overflow of which there is record, and the damage from the deposit of sand and other causes had never before been as great.

The flooded area at Memphis was also much greater than ever before known, a considerable portion of the northern section of the city being covered to a depth of from 2 to 4 feet, and regions heretofore considered far above the high-water mark were submerged. Prompt action, in response to the warnings given, alone saved the gas and waterworks from being seriously damaged. The property loss in Memphis resulted from damage to streets and sewers and piled lumber, with also the loss of wages to employees through the suspension of business, the closing of the mills, etc.

The immediate cause of the overflow in this city was the unusually high stage of the Mississippi River, whose back water caused Wolf River to rise to an unprecedented height, overflowing its banks and forcing the water up Bayou Gayoso into the city.

The operations in connection with the construction and maintenance of all public levees in this river district are conducted by at least three separate levee boards, in conjunction with the United States Engineer Corps. The St. Francis system, with Capt. H. N. Pharr as Chief Engineer, operates in Arkansas; the Mississippi-Yazoo Delta Levee Board has charge of the levees in Mississippi; the upper portion of the system, or what is called the upper Yazoo district, being under the direction of Maj. G. T. Dabney. That portion of the St. Francis system located in Missouri is in charge of the Missouri Levee Board.

As a portion of the funds used in the maintenance of these levees is allotted from the United States Government appropriation for river improvements, the United States Engineer Corps have general supervision of all levee work and other matters pertaining to them.

The purpose of these levees is to prevent the overflow water from the Mississippi River, when out of its banks, from spreading to the surrounding country to the detriment of agricultural and other interests, as well as to the health of the inhabitants. By confining the flow of water within moderate limits, and thus eliminating the almost annual overflow, a vast tract of rich and remarkably fertile land, that was formerly considered uninhabitable and unfit for permanent occupation, has been brought under cultivation and made safe for permanent settlement.

The St. Francis levee system begins near Point Pleasant, which is about opposite the northern boundary of Tennessee, and extends southward in an unbroken line along the west side of the Mississippi River for a distance of 173 miles to the head of Cat Island, near the intersection of the northern boundary line of the State of Mississippi. From thence south to the mouth of the St. Francis River and to the high ground at the foot of Crowleys Ridge, no levee protection at present exists except for a distance of about 15 miles in the vicinity of Walnut Bend in Lee County. It is the intention of the levee board to close the gap of 17 miles between Cat Island and Walnut Bend during the present year.

The distance in a direct line from the high ground at Point Pleasant to the ridge near the mouth of the St. Francis, the proposed terminus of the levee, is 139 miles, but on account of the numerous bends in the river the St. Francis system of levees will, when completed, cover a distance of 212 miles, of which 47 miles are located in Missouri and the remainder in Arkansas. In 1897 the levee only extended as far south as Pecan Point, a distance of 125 miles, so that since the great overflow of that year it has been extended to a point some 70 miles nearer the Gulf. In addition to the extension noted, the whole line from Point Pleasant south, has been raised to a higher grade and strengthened by adding about 12 feet to its base. An entire new levee has also been built to replace that which was found inadequate at the time of the preceding flood.

In 1897 the average height of the St. Francis levee was 9 feet, width of base 62 feet, and width of crown 8 feet. In 1903 the average height was 11 feet, base 74 feet, and width of crown 8 feet. At this height it was expected to hold a stage of water equal to about 38 or 39 feet on the Memphis gage. The levee grade is practically uniform throughout its entire length, but owing to the variations in the topography of the country some sections of the river were brought within narrower limits than others, causing the water to assume different levels. For this reason it was found necessary to raise some portions of the levee considerably above the original grade, while at other points where the river has a greater sweep, the old grade is sufficient.

The estimated cost of improvements, including new levee, since 1897, is \$1,686,000, of which amount the United States Government has paid \$486,000. The estimated cost of the St. Francis levee to date is \$2,875,000. During the present year it is the intention of the levee board to increase the height of the levee to an average of 14 feet, or 3 feet higher than at present, at a cost of about \$650,000.

During the 1897 flood there were three serious breaks in the Missouri section and at least fifteen in Arkansas. In 1898, with 2 feet less water at Cairo than in the previous year, no break occurred, and in 1903, with 1 foot less at Cairo and 3 feet more at Memphis than in 1897, only two breaks occurred.

The Yazoo-Mississippi Delta system of levees begins at the Mississippi State line and extends southward along the east bank of the river to its intersection with the Louisiana system. That portion of the system extending from the high ground 13 miles below Memphis to the northern boundary of Bolivar County, a distance of 123 miles, is known as the upper Yazoo levee, and is in charge of Maj. T. G. Dabney, of Clarksdale. This levee is generally regarded as the best specimen of this character of work to be found in the Delta, and except for the one disastrous break at Flower Lake in 1897, which was due to some unseen flaw in its early construction, it has stood the test of several successive flood waves with no evidence of weakness whatever. As

it now stands, the levee has an average height of 12.5 feet with an additional topping on the crown of 2 feet, making 14.5 feet in all. The width of the crown is 10 feet, with an average base width of 129.5 feet, including a banquette (bank to fortify the land side), which is 40 feet in width. If there were no topping, a stage of 55 feet at Helena would reach the top of the levee, but the topping provides for 2 feet more, or 57 feet on the Helena gage. On the 58 miles of levee between Helena and the State line, enlargements have been made in both levee and banquette over a distance of 38 miles, a topping of from 2 to 4 feet for 17 miles, and new levee for 3 miles, the latter having been necessitated by the Flower Lake crevasse.

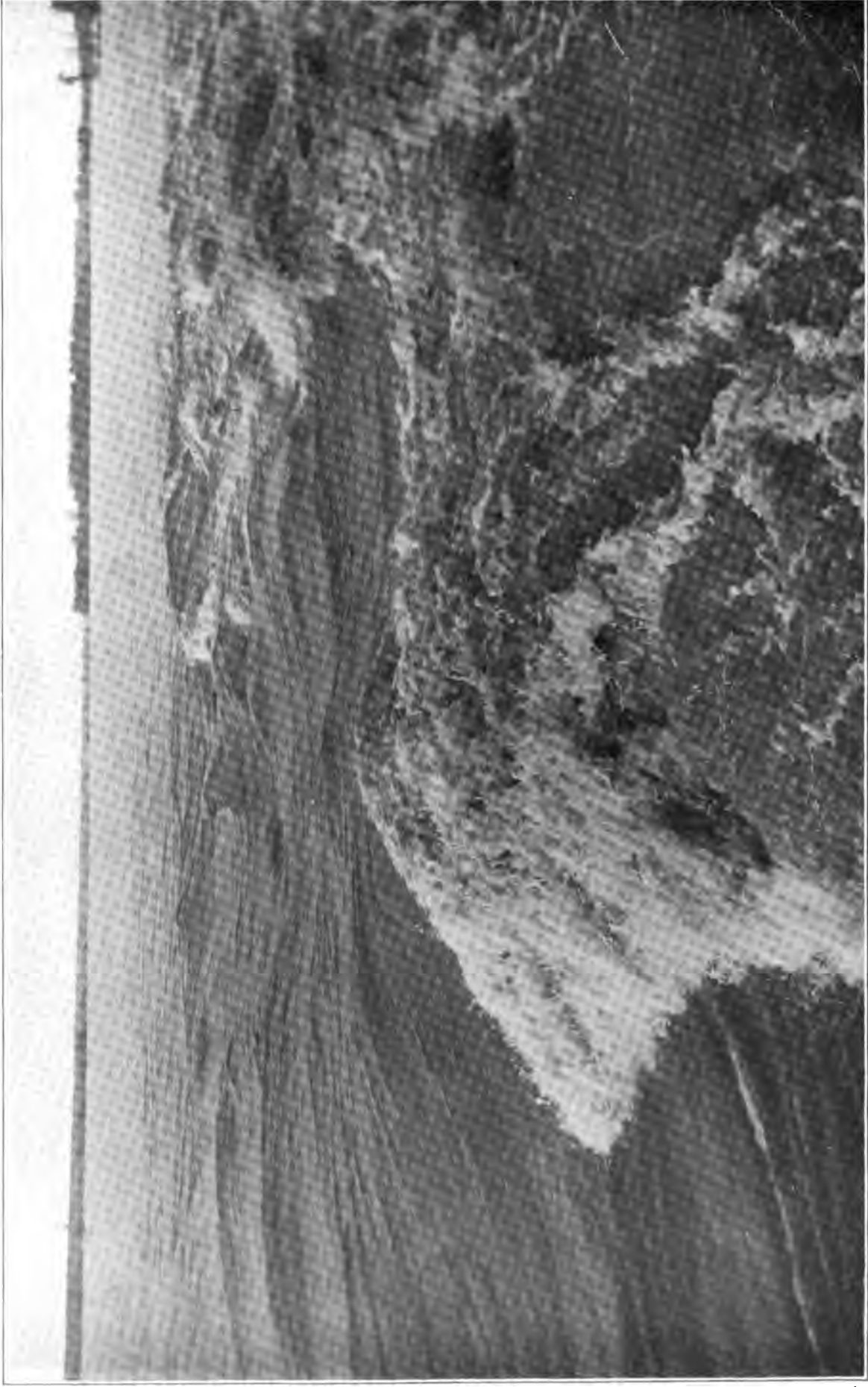
The remarkably high stage of water in the Memphis district during March, 1903, was not due to the presence of an unprecedented volume of water in the river, but rather to the fact that the natural limits of the stream had in recent years been greatly contracted through the extension and enlargement of the St. Francis levee, and the construction of certain railway embankments. Had the same conditions respecting levees and other embankments that obtained in 1882, 1883, and 1886 been in existence at the time of the recent rise, it is unlikely that the maximum stage at Memphis would have exceeded 34 feet, or about the same height reached by the secondary swell that occurred in April of the present year, when the Cairo gage marked 45 feet.

Had the levees remained intact during the March rise, and the entire drainage been made to pass Memphis between the Arkansas levee and the Chickasaw bluff, it is highly probable that the stage at Memphis would have exceeded 41 feet, and there is a strong possibility that it might have reached 42 feet. If this estimate is correct, the levees and railway embankments that have been erected since 1882 and 1883, have had the effect of raising the water during flood periods in front of Memphis between 7 and 8 feet, the latter figure probably being more nearly correct. In 1882 the Cairo stage stood at 51.8 feet on February 26, and a week later Memphis registered 35.0 feet, the difference being 16.8 feet.

In 1883 Cairo had the highest stage ever recorded at that place, 52.2 feet, on February 27, and six days later the Memphis gage indicated 34.8 feet, a difference of 17.4 feet. In 1897 Cairo had 51.6 feet and Memphis 37.1 feet, with a difference between the two of 14.5 feet, or 2.9 feet less than in 1883. In 1903 the highest stage at Cairo was 50.6 feet, while three days later, with two immense crevasses a short distance above, the Memphis gage marked 40.1 feet, the difference being 10.5 feet, a reduction in the gage relation between the two points since 1897 of 4 feet. Had no break occurred in the levee to check the natural rise, this difference would undoubtedly have been reduced to about 9 feet. So that with the same volume of water that passed Cairo in 1882 and 1883, instead of 35 feet at Memphis we would find a gage reading of about 43 feet, provided of course, that the levees remain intact. That is, the extension of the levee from Pecan Point to Cat Island combined with the recently constructed railway embankments have increased the flood plane not less than 5 feet, making a total of nearly 8 feet since 1883.

The following table will show the gage relation between Cairo and Memphis during six important flood periods:

	Cairo.	Memphis.	Difference.
1882.....	51.8	35.0	16.8
1883.....	52.2	34.8	17.4
1886.....	51.0	34.8	16.2
1897.....	51.6	37.1	14.5
1898.....	49.6	37.3	12.3
1903.....	50.6	40.1	10.5



Mississippi River. Rush of water through Holly Bush crevasse, Arkansas.

Comparative stages for 1897 and 1903 at the stations:

	Cairo.	New Madrid.	Cottonwood Point.	Fulton.	Memphis.	Mhoon Landing.	Helena.
1897.....	51.6	40.3	39.3	37.4	37.1	41.6	51.8
1903.....	50.6	39.5	40.0	40.1	40.1	41.8	51.0
Difference.....	-1.0	-0.8	+0.7	+2.7	+3.0	+0.2	-0.8

The above table indicates very clearly the effect of the recent extension and enlargements of the levees between Cairo and Helena. From Cairo to New Madrid the conditions respecting levees being very similar during the two years named, the difference between the maximum stages at those stations is practically the same. From Cottonwood Point southward the increase becomes steadily greater until at Memphis, the 1903 stage exceeds that of 1897 by 3 feet. Again at Mhoon Landing, about halfway between Memphis and Helena, and beyond the influence of the St. Francis levee as now constructed, and where the conditions are the same as in 1897, the difference in stages between the two years is very slight, 0.2 foot, while the gage at Helena shows, within a small fraction, the Cairo difference of 1 foot.

Another factor that is supposed to have been in some measure responsible for the unusual stage at Memphis, and incidentally the flooding of the northern portion of the city and the adjacent territory, is the railroad embankment leading to the west end of the Mississippi River bridge. Formerly the approach to the bridge consisted of several miles of trestle, but within the last three or four years this trestle has been filled with earth, so that from near Bridge Junction to the steel viaduct of the west approach there is now a solid embankment many feet in height. Immediately under the steel viaduct a lower embankment has been erected which runs to the water's edge, the whole forming a complete barrier against the water, which must now find an outlet through the opening between the St. Francis levee and the west end of the railway embankment, or return to the river and pass under the bridge proper.

It has been shown by actual observation that during the recent rise the water on the upstream side was somewhat higher than on the lower or downstream side, and also that the current through the bridge opening was decidedly more rapid than ever before known. All of which seems to indicate that the embankment and the levee combined have caused a ponding of the water at that place. Whether the effect of this congestion near the bridge extends any great distance upstream or to Wolf River, and is sufficient to cause the seemingly unnatural rise in that river, is a question that is now under consideration by the engineers of the Mississippi River Commission and the railroad interests. From the fact that the river in front of Memphis has practically a clear sweep of about 3 miles between the Tennessee bluffs and the line of levee to the west, and the further fact that at least half of this distance has been closed by the railroad embankment running at right angles to the levee, it seems probable that the closing of this space was to some extent the cause of the remarkable rise at this place.

The railroad embankments referred to are located on the low-lying strip of land on the Arkansas side of the river opposite Memphis, known as Hopefield Point.

At a stage of 33 feet at Memphis this strip is practically flooded, while at a stage of 40 feet the whole section is deeply covered and only the highest of the embankments, shown in fig. 1, are visible above the water.

An inspection of fig. 1 shows clearly the local conditions in the vicinity of Memphis.

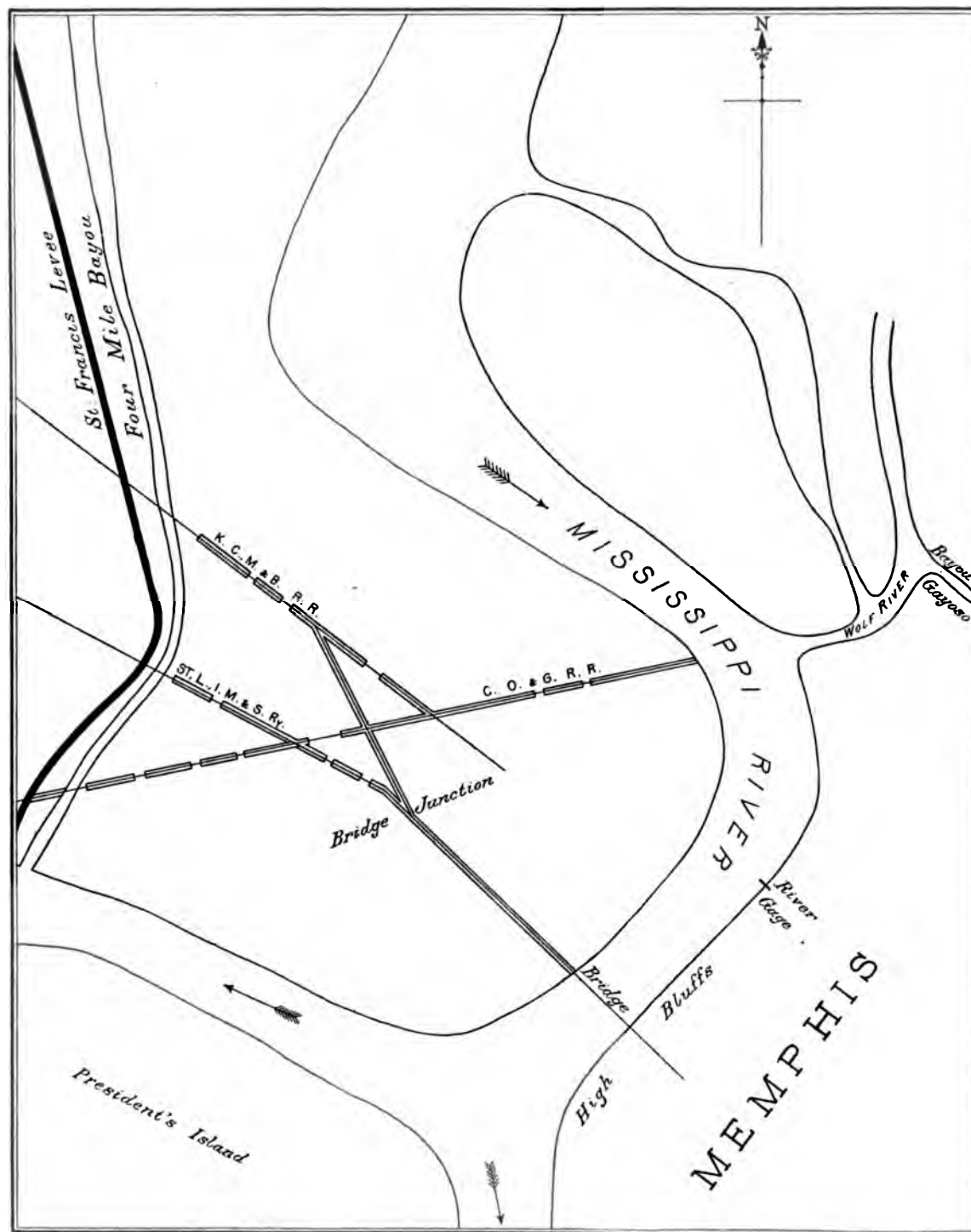


FIG. 1.—Outline map, showing the principal railroad embankments on Hopefield Point, Ark. Also the low ground in the vicinity of Wolf River where the overflow at Memphis, Tenn., occurred.

Most of these embankments are provided with openings consisting of trestlework which afford a passage for the overflow water when not sufficiently high to pass over them. A notable exception to this is the Kansas City, Memphis, and Birmingham Railroad embankment which has the greatest elevation of any here shown, and is the one most objected to. Between Bridge Junction, on the west, and the river bank there



Mississippi River. Flood scene near Pilcher Point, La.

are no openings whatever, and, as there is no escape for the water except through the openings to the west of Bridge Junction, or under the Mississippi River bridge, which ends on the high bluff of the Tennessee side, the ponding previously referred to is supposed to have occurred.

The Mississippi River from below Helena, Ark., to Vicksburg, Miss., by Mr. W. S. Belden, Section Director, Vicksburg, Miss.—On January 1, 1903, the Mississippi River was unusually high from Helena to below Vicksburg, the stage at Vicksburg being the highest on record for that date, but after January 6 the river fell steadily until February 3, when stages ranged more than 20 feet below danger line at all points in the district. Subsequent to February 4 a rather rapid rise began as a result of high water out of the Ohio and its tributaries, and by the close of the month a flood stage was reached. The flood was intensified by the unprecedentedly heavy precipitation in the lower Mississippi Valley during the month of February, which, together with the swell out of the Ohio River, that culminated at Cairo on March 16, caused a continued rise until March 27, when the levee on the Mississippi side broke in two places, one at La Grange, about 3 miles below Greenville, and the other at Albemarle, about 33 miles above Vicksburg; as a result of these breaks the river began to decline.

The maximum stages of the flood and dates of occurrence were as follows: Arkansas City, 53.25 feet, or 11.25 feet above danger line, on March 27 at 2:30 p. m.; Greenville, 49.10 feet, or 7.10 feet above danger line, on March 27 at 11 a. m., and Vicksburg, 51.80 feet, or 6.80 feet above danger line, on March 27 and 28.

On April 3, after the river had fallen about 22 inches, a very unexpected break in the levee occurred on the Louisiana side, about 7 miles below Lake Providence, which proved to be the most serious of the three breaks of the season. The river fell slowly but at a rather uniform rate until April 25, when, owing to a rise out of the Ohio that passed Cairo on April 22, 23, and 24, it remained stationary to rising until May 6, when a rapid fall commenced. By May 11 the river had once more fallen to below danger line at all points within the district.

The flood came early in the season and was below normal in period of duration—two factors that materially modified its destructive features—but for about two weeks the water was higher at Arkansas City and Greenville than ever before known, being 1.35 feet above the high-water mark of 1897 at the former, and 2.35 feet at the latter point, while at Vicksburg the maximum stage fell short of the high-water mark of 1897 by 0.68 foot.

A general statement of the river situation and prospects was issued daily in connection with the weather map and river bulletin. Early in March planters living in the area subject to overflow began to make preparations for high water. Farmers living between the river and the levees, and those located on islands, some of which are protected by private levees, generally moved their perishable property to places of safety early and with little loss. The plantations on Davis Island, which is situated about 25 miles below Vicksburg and comprises about 5,000 acres, most of which is fine farming land, are protected by a private levee that will withstand a stage of 51 feet on the Vicksburg gage. The managers of the plantations on the island not wishing to incur the heavy expense of moving unless it became evident that a stage in excess of 51 feet would be reached at Vicksburg, made arrangements with the Vicksburg Weather Bureau office to give warning to evacuate the island in the event that it became necessary to

do so. The warning was given March 16 and the plantation managers acted promptly, not only saving all perishable property, which was valued at \$40,000, but cut their private levee in such places as to prevent damage by washing and at the same time secure the greatest possible amount of benefit from the overflow that followed. It was subsequently learned that a very rich deposit, ranging from 5 to 6 inches in depth, was secured on the island, that practically no damage was done to the levee, and that planting was only slightly delayed as a result of high water. Only a small per cent of stock was shipped out of the territory protected by the State and Government levees. Mounds of earth were thrown up, rafts and stationary platforms were built, and in not a few instances preparations were made for placing mules, horses, and feed in barn lofts. Machinery and farm implements were generally placed beyond the reach of high water. For more than three weeks railroads and river transportation companies were kept very busy handling supplies and provisions shipped into the localities where overflow was anticipated, and the railroads were active in protecting their own interests by hastening men and material to points where danger was apprehended. Levee engineers in the district were furnished the river reports and weather and river forecasts by telephone daily from the Weather Bureau office at Vicksburg in order that they might be fully and promptly informed concerning the conditions that confronted them, and they were thus assisted in their endeavors to hold the levees intact by raising and strengthening those sections that seemed insufficient to withstand the tremendous force of the water.

As the crest of the flood approached Arkansas City and Greenville boats were required to run at reduced speed in order to prevent large waves, as the water was nearing the crown of the levees in many places. Guards patrolled the levees night and day, and at frequent intervals men and material were held in readiness to respond to calls of danger. At the time of the La Grange break a force of men was working on the levee which showed signs of weakening, but a stretch of the levee gave way so suddenly that it was only after great effort that several of the laborers escaped with their lives. Owing to the very rapid rise of the water within a few miles of the break there were several other narrow escapes, but no lives were lost. The water from the crevasse, which occurred on the La Grange plantation, flowed rapidly across the Hollywood, Harford, and Swiftwater plantations into Swiftwater Bayou, and thence southward inundating the entire country between the Mississippi River and the embankment of the main line of the Yazoo and Mississippi Valley Railroad to a depth ranging from 2 to 10 feet. At the same time backwater advanced northward and overflowed Greenville. Considerable damage was done by the overflow in the immediate vicinity of the break, where about 200 acres of fine farming land were badly washed and left covered with white sand to a depth of from 1 to 4 feet, but beyond 4 or 5 miles from the break very little damage was done as compared with former overflows, although railroad traffic was suspended on the main line of the Yazoo and Mississippi Valley Railroad, between Vicksburg and Leland, from March 27 to April 17, and on the Riverside division of the same road, between Rollingfork and Greenville, from March 27 to May 7. Other railroads suffered comparatively little inconvenience on account of the flood. A total of about 70 head of stock was drowned; 19 mules were lost on the La Grange plantation, and other losses of stock generally occurred in and around Black Bayou Swamp, where the overflow water was the deepest. About half of the city of Greenville was overflowed

to a depth of from 1 to 6 feet, necessitating the evacuation of 115 houses. No stock was lost in the city.

The La Grange crevasse attained a width of 3,875 feet, but by April 20 the water had receded sufficiently for the work of closing the break to begin, and within ten days closure in deepest water was finished. This allowed the water to run off of the inundated country about two weeks earlier than it would otherwise have done. The crevasse at Albemarle attained a width of 1,100 feet and was of minor importance, owing to the fact that the country back from the levee had been previously overflowed by backwater from the Yazoo River.

The total area inundated in the Yazoo basin amounted to 1,460 square miles, but only about 810 square miles of this were due to crevasse water, as about 650 square miles were inundated before the crevasses occurred by water coming around the lower end of the levee system and backing up the Yazoo River and its tributaries. Farm lands constitute about 50 per cent of the 1,460 square miles of inundated territory, which has a population of about 60,000, more than 50,000 of whom are colored. The planting of crops was not seriously delayed by this overflow.

At the time of the Hollybrook crevasse there were about $4\frac{1}{2}$ feet of levee above the water. The levee itself was 18 feet high and was back from the river about 3,000 feet. The rapid flow of water through the crevasse, which occurred on a plantation owned by Mr. J. G. Pittman, and across adjacent country, did much damage by washing farm lands and destroying farm buildings, but no lives were lost. Preparations to close the crevasse, which attained a width of 3,300 feet, were not commenced until the latter part of May, when the water had ceased flowing through the channel. The delay thus caused in beginning farm work in the overflowed district, comprising about 930 square miles, was the most serious feature of the overflow on the west side of the river.

As a rule, the levees, which have practically the same location as in 1897 and protect practically the same territory, are back a few thousand feet from the river, and in following its sinuous course they make some rather sharp curves. The improvements consist of additions to the height and body of the embankments, but owing to a shortage in available funds for use in constructing levees they are generally below what is known as standard grade. Those sections of levee which, for various reasons, would be difficult to temporarily raise in time of high water, have generally been most enlarged, while those that will admit of work during flood stages have been given less attention. On the west side of the river, from Helena to Vicksburg, the height of the levees has been increased since 1897 by an average of nearly 3 feet and the width about 24 feet, while on the opposite side the height has been increased from 2 to $2\frac{1}{2}$ feet and the width from 22 to 25 feet.

The dry weather that prevailed during the last ten days of March and throughout the month of April was very favorable for those compelled to live in temporary quarters during the extremely high water.

Mississippi River and tributaries below Vicksburg, Miss., except the upper Red River. By Mr. I. M. Cline, District Forecaster, New Orleans, La.—The flood in the lower Mississippi, which commenced in March and reached its maximum in April, 1903, exceeded all previous high-water records, and hence is a matter of more than ordinary importance.

In considering floods in the lower Mississippi there are two streams which require special attention, the Mississippi proper and the Atchafalaya. The Atchafalaya acts

in a dual capacity. It connects with the Red River about 7 miles above the mouth of that stream, and is practically a continuation of the Red River. The principal function of the Atchafalaya is to carry off the discharge of the Red River, but when that stream is at low stages and the Mississippi is high, a large volume of the flood waters of the Mississippi is carried to the Gulf through the Atchafalaya. Another stream through which the Mississippi discharges before reaching New Orleans is Bayou Lafourche, which leaves the Mississippi above Donaldsonville. In the issue of forecasts and warnings all of these streams must be considered, together with the part likely to be played by levees which line their banks.

On February 7, 1903, the stage of the Mississippi at New Orleans was 9.2 feet, and the Atchafalaya at Melville was 25.3 feet. A steady rise then commenced. The first flood warning was issued February 26, advising the public that the river would go above the danger line. On March 7 a stage of 20 feet for New Orleans was forecast. In view of the possibility of a higher stage than 20 feet, and the fact three or four weeks of vigorous work would be required to strengthen and raise weak places in the levees, so that they would stand a higher stage and prevent extensive and serious overflows, a careful study of the situation was made during the 8th, and the volume of water in sight from the several tributaries of the lower Mississippi was taken into consideration. It appeared evident that if the levees above New Orleans could be made to carry the volume of water then in sight, a stage of 21 feet would be reached at New Orleans. On account of the seriousness of the situation, and the fact that several million dollars' worth of property was threatened with total loss unless warnings were given in sufficient time to enable protective measures to be arranged, which would require three to four weeks to accomplish, the following long range special flood warning, predicting unprecedented high water, was issued Monday morning, March 9:

"The Mississippi River is now within 1.4 feet of the highest water ever recorded, and the Atchafalaya within 1 foot of the highest water on record. These rivers will continue to rise slowly during the next three or four weeks, and all interests are advised to prepare for a stage of 21 feet at New Orleans and a corresponding rise in the Atchafalaya, if levees hold volume of water now coming."

This warning was telegraphed and mailed to every town and village in the Mississippi bottoms from Vicksburg to the Gulf of Mexico. Warnings for stages of 39 feet at Melville, on the Atchafalaya, and 37 feet at Alexandria, on the Red, were issued March 12, and warnings for 45 feet at Monroe, on the Ouachita, were issued on March 14. Special bulletins were issued daily from March 9 until April 11, 1903, repeating the above warnings and giving such information and advice as would best serve public interests, and were mailed regularly to all post-offices in the Mississippi bottoms south of Vicksburg. The press published the bulletins and gave them wide distribution. These bulletins were greatly appreciated by the public, even beyond the borders of the State of Louisiana.

The estimate placed on the value of these warnings in this vicinity is shown in the following extract from a letter from the New Orleans Cotton Exchange:

"NEW ORLEANS, *July 3, 1903.*

"Dr. I. M. CLINE,

"Forecast Official, West Gulf Forecast District.

"DEAR SIR: The warning issued by the United States Weather Bureau in the early days of March, 1903, practically four weeks before the highest water occurred, advising



Repairing levee at Lagrange, Miss.

the people of the lower Mississippi to prepare for a stage of 21 feet at New Orleans, 1.5 feet above previous highest water, and corresponding high water in the Atchafalaya, within three or four weeks, caused vigorous measures to be taken to raise and strengthen levees throughout the State. The warnings having been issued about four weeks in advance of the flood waters, stating accurately when the high water was expected to occur, enabled successful measures to be taken which prevented overflow, and has thus resulted in saving to the people of this section of the country several millions of dollars which without warning or with a warning of only a few days would have been lost.

"Yours truly,

"HENRY G. HESTER,

"J. P. SCHNEIDER,

"Secretary.

"*Chairman Committee on Information and Statistics.*"

The causes of the unprecedented high water of 1903 are not hard to find. The Red and Ouachita rivers were high at the opening of the year, the stage at Alexandria, on the Red, being 32 feet, and at Monroe, on the Ouachita, 31.4 feet. General rains over the drainage basins of these streams maintained them at relatively high stages during January, February, and March. The rain also extended over the Arkansas, Yazoo, and other smaller tributaries of the lower Mississippi and caused them to reach high stages during March. High water occurred during February and March in the Tennessee, Cumberland, and Ohio rivers. Every tributary of the Mississippi from the Ohio south was carrying an unusually large amount of water during February and March, a condition which has not previously existed. Heretofore floods have resulted from the discharge of waters from the eastern tributaries, while the western tributaries remained low, but this year both the western and eastern tributaries were discharging floods into the Mississippi almost simultaneously. The Red and Ouachita carried a volume of water which was beyond the capacity of the Atchafalaya to discharge, and a large volume of water from these streams was thrown into the Mississippi, which has not been the case in previous floods. Heretofore the capacity of the Atchafalaya was not taken up in carrying the waters from the Red and Ouachita rivers, and it acted as a mouth to the Mississippi, carrying a large volume of the Mississippi flood waters to the Gulf; but this year matters were reversed, and instead of the Atchafalaya relieving the Mississippi of a portion of the water, it forced a large portion of the flood waters from the Red and Ouachita rivers into the Mississippi, which intensified the situation in the lower Mississippi.

The Mississippi and Atchafalaya rivers rose steadily from February 7 until early in April. The stages reached were practically those forecast, and are as follows: New Orleans, 20.4 feet, April 6 and 7, and for a few hours the stage was reported at 20.7 feet; Melville, 38.7 feet, April 5 and 6, just about four weeks after the warnings for such stages were issued. The Red and Ouachita rose until about the last of March, and floods forecast two weeks in advance were practically verified by the following stages: Alexandria, 36.2 feet, March 27; Monroe, 44.5 feet, March 26 to 28.

When the warning for a stage of 21 feet at New Orleans was issued the opinion that no such stage would occur was freely expressed by some members of levee boards and others. As the people of the lower Mississippi had not had previous experience with so complicated a flood, there were many who did not believe that unprecedented high water would occur. The only publication in this section, however, which expressed lack of confidence in the warnings of the Weather Bureau was the Louisiana Planter, which on March 14 expressed doubt about the river going above 20 feet at New Orleans, and under date of March 21, 1903, in speaking of the high water, said:

"We have therefore not yet reached the flood height of 1897 at New Orleans, and as we stated in our issue of last week, we are quite skeptical about the river here reaching the 21-foot high-water mark so confidently urged by our Weather Bureau, and further than this we are led by our observation to doubt the making of a 20-foot record at New Orleans this season. Still this latter may come."

On the contrary, the daily press urged that the Weather Bureau warnings be heeded, as is shown in the following from an editorial in the Times-Democrat of March 16, 1903, advising the levee board to continue emergency improvements:

"It must now be clear, however, that the board should not relax its efforts to strengthen the levees in this district. The river, which is already high, will certainly rise even higher within the next fortnight. Indications are now plentiful that the waters, which now touch the gage at 19.3 feet will, before April 1, go as high as 21 feet. In its official report the Weather Bureau has warned the public to prepare for such a rise. This warning can not be disregarded with impunity."

Height of the levees is not the only matter which causes concern and anxiety during high water. All the levees may be much above the height of the threatened flood, but still great danger of overflow is always threatened from caving in of the banks of the river, carrying the levees with them. In addition, muskrats and crawfish undermine the levees, and disastrous breaks result from these causes. As a precaution in case of crevasses caused in this manner, materials used in closing breaks are placed on barges and railroad trains at convenient places as soon as warnings for high water are issued, so that they can be rushed to the break with the least possible delay.

Notwithstanding there were many who did not hesitate to openly question the warnings for a stage of 21 feet at New Orleans, the fact that the warnings had been issued by the United States Weather Bureau caused all those interested in high water to take active and vigorous measures to combat a stage which would give 21 feet at New Orleans and 39 feet at Melville. Levee boards met Monday, March 9, as soon as possible after the warning was sent out, and arrangements were made to commence the work of strengthening the levees so they would carry the stages forecast. All levees which were not sufficiently high to carry 21 feet of water were raised with sacks of earth and plank. The greater portion of the river front of New Orleans was raised 2 to 4 feet.

A large emergency levee was thrown up at the foot of Canal street, 4 blocks from the Weather Bureau office. Similar emergency improvements were made throughout the district. While the levees were being raised and strengthened, preparations were also made for closing any crevasses that might be caused. Trains and barges were loaded with such material as would be needed, and kept in readiness at convenient places, from whence they could be summoned without delay. There were at least two instances where great loss was without doubt averted by these advance preparations, and some special mention of them will be made in the discussion of crevasses.

The first breaks in the levees occurred early on the morning of March 9, in Terrebonne Parish, about 40 miles above the mouth of Bayou Lafourche and about 8 miles below Lockport. Two crevasses about 1 mile apart occurred in the right bank. One was 40 feet and the other 125 feet wide. The greater portion of the country flooded by these crevasses is devoted to truck farming, and heavy losses were experienced. No efforts were made to close these breaks until early in April, and the work was completed by the middle of that month.

At Arlington, about 5 miles below Baton Rouge, the old levee on the left bank of

the river had been caving, and was not considered safe. A contract had been let for a new levee some months before the flood, work on which was progressing slowly at the time the flood warning was issued by the Weather Bureau. As a result of this warning vigorous measures were taken to strengthen a protection levee around the cave sufficiently to hold the stage of water forecast and a disastrous overflow was thus prevented.

March 19 a break occurred below Bougere Landing, on the right bank, in Concordia Parish. This break occurred in a levee or embankment built by the Texas Pacific Railway. The embankment was constructed in 1902, was 100 feet wide at the base and 15 feet high, and a gap 2 miles wide was cut in it. The country subject to overflow from this break is low and swampy. The overflows in this vicinity run into the Red River and pass out to the Gulf through the Atchafalaya, or come back into the Mississippi when the Atchafalaya is at flood stage. Aside from the loss to the railway company very little damage resulted from this overflow. The break remained open during the high water.

About 4:30 a. m., March 22, a break occurred in the levee on the right bank of Bayou Lafourche, about 3 miles above Thibodaux, in front of the Waverly plantation, and soon widened to 200 or 250 feet. The water from this crevasse flooded several plantations along the bayou front, and flowed out through the swamps of Chacahoula, Gibson, Bayou Boeuf, and Berwick Bay. Considerable damage resulted, but private protection levees had been thrown up and these prevented the water from reaching several plantations which would otherwise have suffered. The main line of the Southern Pacific Railway is built on an embankment which acted as a protection to the territory to the south of this break. The towns of Gibson, Donner, Pugh, Labadieville, and Tallien were flooded. This crevasse was closed in April.

A break, 250 feet in width, occurred in the levee on the left bank of the Mississippi, 6 miles below Pointe a la Hache and about 50 miles below New Orleans, on the morning of March 15. This break fortunately occurred in a barren country and there was no damage, except possibly to oyster beds in the vicinity of the crevasse, which increased in width until it was probably 1 mile wide. This break remained open during the high water.

The most important crevasse in the history of the flood occurred about 11 p. m., March 26, on the right bank of the Mississippi about 40 miles above New Orleans, in front of the Hymel plantation, and hence styled the Hymelia crevasse. The levee stood 5 feet above the water and was considered one of the safest in the district. It is probable that the crevasse resulted from a muskrat hole, or perhaps a crawfish hole, which allowed the water to undermine the levee. When the crevasse was discovered it consisted merely of a hole about 10 feet in diameter in the base of the levee. This hole cut rapidly, the top caved in, and the crevasse was soon created. The water cut the levee very fast, and within three hours the crevasse was over 200 feet wide, and on March 30 was 600 feet wide. Vigorous action was taken to close the break and by March 28 1,000 laborers were at work endeavoring to build a crib work 3,000 feet across the overflowing waters. The batture on which the work was being prosecuted was sandy and the water cut under the cribbing, rendering the work very difficult, and frequently washing the cribbing out. Work was pushed with vigor day and night, and everything within the power of man was done to check the flow of water which was rushing through the crevasse. Through stubborn and persistent efforts the cribbing

was completed across the crevasse on April 2, and filling in with sacks of earth was pushed vigorously. On April 7 a barge loaded with sacks of earth struck the cribbing and wrecked it, and 50 feet of the cribbing were washed out April 8. Further breaks in the cribbing occurred during the next two or three days, and the efforts to close the crevasse were not successful, notwithstanding the unremitting toil and labor. The work was finally abandoned during the early part of May.

On March 31 published estimates as to the damage which would result from the Hymelia crevasse, should efforts to close it prove a failure, placed the possible total damage at \$25,000,000. The cribbing, filled in to a greater or less extent with sacks of earth, which extended around a good portion of the crevasse all the time, checked the outflow, and as a result only a small portion of the area subject to overflow from that crevasse was actually covered with water. Private protection levees had been thrown up around several plantations when flood warnings were first issued, and these served to turn the water from the crevasse into Lake des Allemands and bayous, about 5 miles back from the river. The greatest width of the overflowed area along the river front was probably 20 miles. Several villages were flooded, but it is not believed, however, that the total damage which resulted from this crevasse amounted to more than \$2,000,000, or about one-tenth of the amount estimated soon after the break occurred. Approximately \$200,000 was spent in the attempt to close the crevasse.

The private levee around the State Farm at Angola, on the left bank of the Mississippi, broke at 3:30 p. m. Tuesday, March 31. This levee was not expected to stand the high water, and everything had been moved to places of safety. This being in the cotton growing section, the only damage resulting from the crevasse was the delay in the planting of crops.

On April 5 a crevasse occurred at Magnolia, on the right bank of the Mississippi, about 36 miles below New Orleans. This crevasse was a remarkable one. The river at that point is 120 feet deep, and the levee was 10 feet high, with a batture 150 feet wide in front of it. The batture and levee caved into the river and caused a crevasse about 100 feet wide. Where the levee stood the water was soon 60 feet deep. The Fort Jackson and Grand Isle Railway runs down the right bank of the Mississippi from Algiers to Buras. As a precaution, when the Weather Bureau issued the warnings for high water, a train was loaded with such material as would be required to close a crevasse and kept in the yards at Algiers ready for prompt dispatch. When the break occurred this train was at once ordered to the scene and the necessary labor was collected. On account of these precautions having been taken, a crevasse which threatened to be one of the most serious in the history of the flood was successfully closed in ten hours. If the emergency train had not been ready, the closing of this crevasse would have been very doubtful, and had it remained open some of the finest sugar plantations in Louisiana would have been flooded and great damage would have resulted. "A further delay of one hour would have precluded any hope of closing this crevasse," says Major Richardson of the State Board of Engineers. This means that the precautions taken in this instance as a result of the Weather Bureau warnings saved to the people of that section several million dollars.

On April 13, about 5 p. m., water was discovered flowing through a crawfish hole under Waterloo levee on the left bank of the Mississippi River near New River station, in Ascension Parish, about 90 miles above New Orleans. When discovered, the water



Mississippi River. Constructing cribbing, Hymelia crevasse, Louisiana.

had cut a hole 18 inches in diameter, and unless checked immediately would have developed a crevasse that would have flooded one of the richest sugar growing sections of the State. Precautions had been taken, however, in this section so that materials and everything necessary to close a break were ready to be moved at once to the scene. Ten thousand sacks of earth were piled around the opening on the afternoon of April 13, and four days' hard work devoted to repairing the levee.

The area protected by levees in this district in 1903 is practically the same as that protected in 1897 (see Chart II). Levees were raised 2 to 5 feet generally between 1897 and 1903, and extensions have been made in different places. Altogether about 50 miles of new levees have been constructed since 1897. Extensive and effective emergency improvements were also made during the four weeks following the issue of the warning advising the public to prepare for unprecedented high water in this section.

Practically all of the area flooded in this district is above the mouth of the Red River, and with the exception of a small area between Bougere and the mouth of the Red River, the waters which overflowed that territory came from a crevasse in the Vicksburg district known as the Hollybrook crevasse.

Red River at and beyond Shreveport, La., by Mr. J. W. Cronk, Observer.—An enormous loss to all interests in the Red River Valley was the unavoidable result of the flood during February, March, and April, 1903.

Sufficient time had not elapsed since the great flood of the last two months of the year, 1902, to admit of the necessary repairs being made at the scene of the crevasse at Elmer Bayou (Johnson's Place), and at other places. The high waters of the early part of the present year, therefore, found the levees in a very unprepared condition to withstand a flood, and the result was especially disastrous to the country north of Shreveport over a strip about 25 miles in length by from 1 to 6 miles in width, in Caddo Parish, where railroad traffic was entirely suspended on the Texarkana, Shreveport, and Natchez branch of the Texas and Pacific Railway, for about two months.

The damage to levees alone, in this section, will amount to hundreds of thousands of dollars, and the loss to farming and commercial interests will also be very heavy, principally from the enforced delay in planting of crops on lowlands, and the general interruption of business. Stock of all kinds was fully protected, preventing loss of that class of property, to which end the Weather Bureau was largely instrumental, as the warnings and forecasts were so timely that ample opportunity was afforded to all to collect and move herds of cattle to places of safety. Ample time was also given for the removal of families from the lowlands without loss of life. Two or more persons, however, lost their lives by accidental drowning during the flood.

At Shreveport the flood was characterized by one long, steady, and uninterrupted rise, from a gage reading of 7.4 feet, on February 3, to a little above the danger line of 29 feet, on March 2, and to a maximum gage reading of 33.1 feet, on March 22 and 23. The fall was also steady and uninterrupted, and the danger line was once more reached on April 5. By the end of the month the stage was but a little above 6 feet.

At Fulton, 116 miles by river above Shreveport, four separate rises were noted, but they were so close to each other that only their combined and somewhat erratic effect was evidenced in the one rise at Shreveport above mentioned. The crests of the four rises at Fulton, with a fall to below danger line of 28 feet preceding each, were recorded

as follows: 30.5 feet, on February 20 and 21; 29.6 feet, on March 5; 31.2 feet, on March 14; and 28.5 feet, on March 25.

At Arthur City, 123 miles by river above Fulton, the highest water recorded during the flood period in the valley below was only 21 feet on March 2, or 6 feet less than danger stage. It is apparent from this that the flood in this district was comparatively local and that deductions for forecasts and warnings were necessarily dependent upon rainfall reports to a large extent.



Mississippi River. Hymelia crevasse, Louisiana.

THE MIDDLE MISSISSIPPI AND LOWER MISSOURI FLOODS.

Introductory.—The floods of May and June, 1903, in the middle Mississippi and lower Missouri valleys have created for themselves a history unparalleled in the high-water annals of our country. At some places the stages of the water exceeded any previous known records; at others, while the maximum stages had been exceeded once or at the most twice before in our history, whether recorded or traditional, they have been instrumental in placing upon a solid foundation of truth a record that has never until now been able to stand upon a higher plane than that of an indifferently authenticated tradition. Reference is had to the great flood of 1844, when stages of 41.4 and 37 feet were recorded at St. Louis and Kansas City, respectively. The stage at St. Louis has never been seriously questioned, but that of 37 feet at Kansas City has always been the subject of more or less dispute and discredit on the score of impossibility. However, the experiences of the present year have served to convince the hitherto skeptical that stages of water beyond even that of 1844 are not impossible at Kansas City with a proper combination of the necessary contributory conditions.

Greater weight will also be given in future to the traditions of the great flood of 1785, "l'année des grandes eaux," as it was appropriately designated by the old French settlers. During this flood the stage of water at St. Louis, reduced to the zero mark of the present river gage, was 42 feet, and the time probably June. Some details regarding this flood will be found in the report by Mr. E. H. Bowie relative to the flood of the present year at and near St. Louis. Mr. Bowie has included in his report a history of the previous great floods in the middle Mississippi Valley, especially that of the year 1844, and it is thought that the interest that naturally attaches to the subject at this time will be a sufficient explanation of its presence in this report.

Losses of life and property.—In a more material sense, too, the floods of 1903 marked a new epoch in our economic history. The floods of 1785 and 1844 ran harmlessly over unbroken forests and bottoms, tenanted only by the beasts of the field and birds of the air, save along the Kaskaskia bottoms and the adjoining ones of the Mississippi, where were the little farms of the French colonists. The floods of 1903 descended upon broad, fertile, and highly cultivated fields, and upon rich valleys filled to overflowing with vast industries devoted with never ceasing energy to the fulfillment of the insatiable demands of commerce.

The resulting ruin and desolation were beyond description, and would tax even the most vivid imagination to contemplate. The number of human lives lost will never be accurately known, but the total number reliably reported was exactly 100, of which more than one-half were reported from Kansas City westward. The losses to property

were practically beyond computation. Estimates, which are far from complete, place the total losses at \$40,000,000, over two-thirds of which can be attributed to the work of the Kansas and lower Missouri rivers.

Causes of the floods.—A merely casual inspection of the rain chart for the month of May, 1903 (see Chart XV), will suffice, in a general way at least, to show the reasons for the floods, which in most instances, were very destructive.

These rains were excessive and almost continuous during the latter half of the month, especially during the last ten days, over the middle Mississippi Valley, the western portion of Oklahoma, and the eastern portions of Kansas and Nebraska, and were due to the persistent barometric depression over the eastern slope of the Rocky Mountains and lower Missouri Valley. The actual quantity of rainfall during the month of May over the districts affected by the floods varied from about 5 to 15 inches, 2 to 11 inches above the normal quantity for the season of the year, and of this enormous quantity over one-half, and in some localities, over two-thirds fell during the eleven-day period from May 21 to May 31, inclusive. Over the southeastern and extreme eastern portions of the State of Nebraska, from Webster County east to the State line, and thence north to Dakota County, the precipitation for the month varied from 11 to 16 inches; over the western two-thirds of the State of Iowa there were from 8 to 12 inches, with a maximum fall of over 15 inches in the extreme southwestern portion of the State, while in the extreme southwestern and extreme northwestern portions of the State of Missouri, and the eastern portion of the State of Kansas, the amounts ranged from 10 to 14 inches. The flood conditions were also intensified and aggravated by the fact that the close of the winter left the soil of the river valleys in a very moist condition, and incapable of absorbing any considerable quantity of water in addition. The ratio of rainfall to run-off was thereby considerably increased and much more water found its way into the rivers, with the result that the discharge volumes were increased largely beyond the normal output from an equal quantity of precipitation.

Districts affected.—The States principally affected by the floods were Illinois, Iowa, Missouri, and Kansas, and in a minor way, small portions of southeastern Nebraska, southeastern Minnesota, and southwestern Wisconsin. These comprise portions of the watersheds of the Mississippi and Missouri rivers with their principal tributaries, chiefly the Des Moines and Kansas rivers.

Duration of the floods.—The floods may be considered to have begun on May 26, when the Kansas River and its tributaries were bank full, with many already overflowing; and to have continued until June 18, on which date the Mississippi River at St. Louis first fell below the danger line. This would make the total length of the flood period twenty-four days, although in the individual rivers it was not so extended. In the Missouri Valley, under the conditions named above, the flood lasted from May 26 to June 11, both dates inclusive, a period of seventeen days, the lower Missouri falling below the danger line on the latter date. The Mississippi flood continued from June 2 to 18, inclusive, also a seventeen-day period. The river at Dubuque reached the danger line of 15 feet on the former, and fell below the 30-foot danger point at St. Louis on the latter date. There was, however, some moderately high water north of Dubuque during the latter half of May. By a curious coincidence, the Des Moines River flood also continued for seventeen days, beginning with May 28, when the river at Des Moines

first rose above the danger line of 19 feet, and ending June 13, when the Mississippi, at Keokuk, near the mouth of the Des Moines River, first fell below the danger point of 15 feet.

The following table shows the number of days the various rivers were above the danger lines during the floods:

Number of days rivers were above danger lines, May and June, 1903.

Stations.	Danger line.	At or above danger lines.							
		Total.	1 foot.	3 feet.	5 feet.	7 feet.	9 feet.	11 feet.	13 feet.
Dubuque, Iowa	15	8	0	0	0	0	0	0	0
Keokuk, Iowa	15	14	12	8	0	0	0	0	0
Hannibal, Mo.	13	23	21	16	12	10	3	0	0
Grafton, Ill.	23	13	11	8	3	0	0	0	0
St. Louis, Mo.	30	16	16	12	10	7	0	0	0
Chester, Ill.	30	11	9	3	0	0	0	0	0
St. Joseph, Mo.	10	11	9	4	1	0	0	0	0
Kansas City, Mo.	21	14	12	10	9	7	6	4	3
Boonville, Mo.	20	13	13	10	8	6	4	0	0
Hermann, Mo.	24	9	8	5	2	0	0	0	0
Des Moines, Iowa	19	6	5	2	0	0	0	0	0
Beardstown, Ill.	12	20	12	0	0	0	0	0	0

Extent of overflow.—No previous flood in this country, nor perhaps in any other, extent of damage alone considered, wrought so great havoc among the cities as did that of 1903. In the city of Des Moines between 8 and 9 square miles of municipal territory were submerged, while at Hannibal about all of the southern, as well as those portions of the northern and western districts immediately adjacent to the Mississippi River and Bear Creek, met a similar fate. In Kansas City and vicinity approximately 5 square miles of territory were overflowed, as was also practically the whole of the northern portion of the city of Topeka. Very little of the cities of St. Louis and East St. Louis were covered, but large portions of the manufacturing towns of Venice and Madison, through the breaking of their levees, were flooded to a considerable depth. In all there were between 3,000 and 3,500 square miles of territory overflowed and of this, at least one-half, was under cultivation. Over the cultivated area, the crops, of course, were ruined, but a large proportion was at once replanted and soon gave promise of a bountiful yield.

Levee protection.—There were no levees of consequence along the Missouri and Kansas rivers, nor were there any along the right bank of the upper Mississippi except at Muscatine and at scattered places between Alexandria and West Quincy. On the left bank, however, there are the Hunt, Lima Lake, Indian Grave, and Sny levees, extending from Warsaw to the bluffs near Hamburg, a distance of 110 miles. Of these, the most famous is the Sny, which extends from below Quincy to Hamburg, a distance of about 65 miles. There are also local levees at Des Moines and on the right bank of the lower Skunk River; the Egyptian levee, on the right bank of the lower Des Moines River, and dikes protecting East St. Louis and towns immediately above. Not one of these remained intact except that near Muscatine. Those at Des Moines began to give way on May 29, those along the lower Des Moines on May 31, and on Skunk River on June 4. On the night of June 3 the Hunt, Lima Lake, and Indian Grave levees broke. On June 5 a 300-foot crevasse was made in the Sny levee almost directly

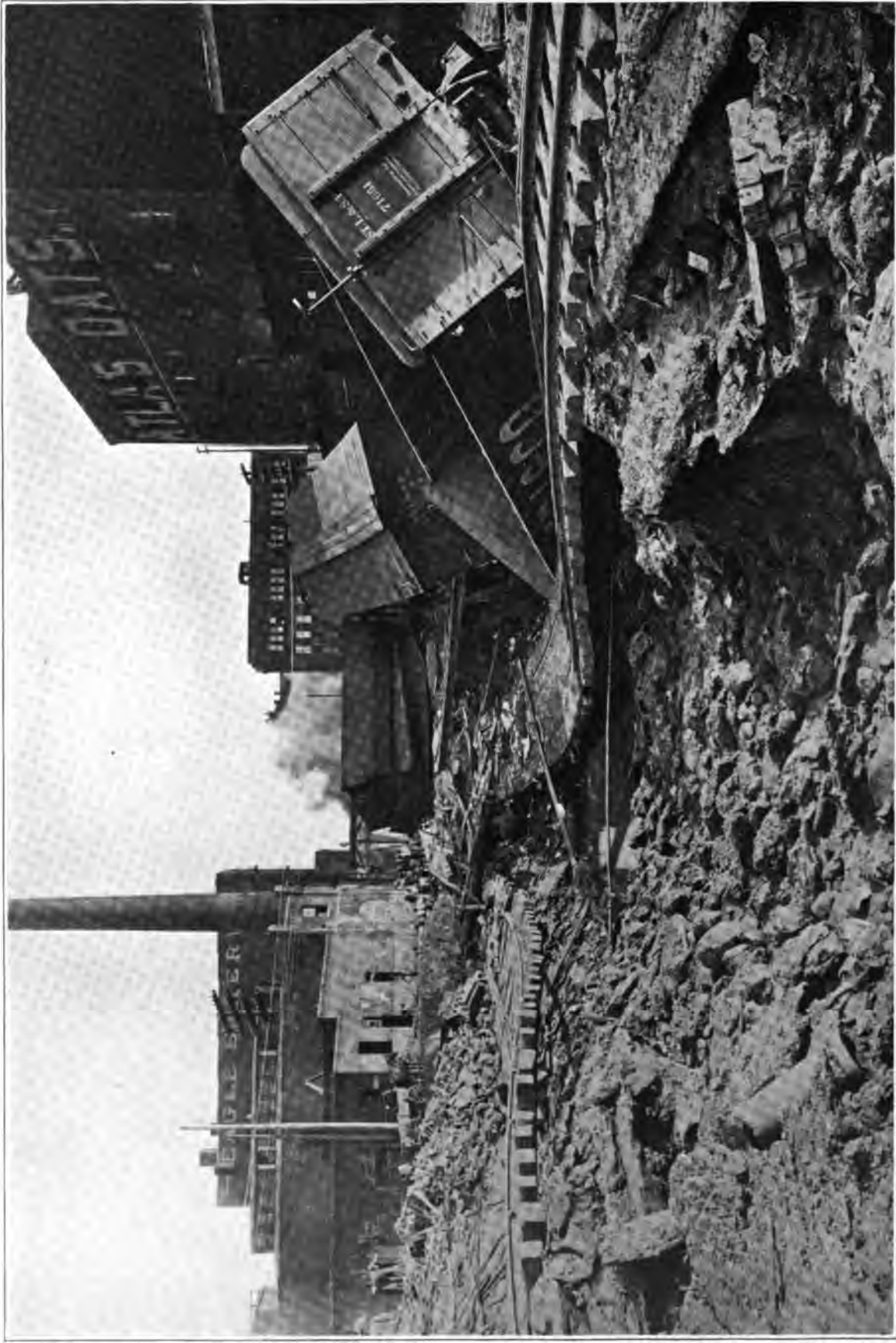
opposite the town of Louisiana. The first breaks opposite St. Louis also occurred on the night of June 5 and were followed by others during the five succeeding days.

Effects of encroachments upon river banks.—In some places where the flood planes were abnormally raised, opinions differed as to the effect of embankments, bridges, and other encroachments upon the natural channels of the water. At Topeka the damming effect of the Rock Island and Melan bridges was a subject of some controversy, because the bridge approaches, which encroached somewhat upon the river bed, already narrower than on either side, were solid embankments, instead of open spans or arches. The weight of opinion indicates that these bridges accelerated the flood at North Topeka, but had no effect upon the final result. The former conclusion is doubtless correct, but the latter is not so apparent. If the water had been allowed an unobstructed flow it naturally follows that it would have moved faster, with a consequent lowering of the flood plane behind the bridges. With a flood of such magnitude as that of 1903, the bridge effect was doubtless minimized, but was, nevertheless, exerted to considerable extent. In the vicinity of Kansas City, the effects of bridges and bank encroachments were very marked and attention is particularly invited to the remarks on this subject by Mr. Connor in his report of the flood in that district. The effects of narrowing the Kaw Channel from 900 feet to 600 and 500, and in some places to 400 feet, and that of the Missouri from 2,000 to 1,120 feet are self-evident and no discussion could make them more so.

Comparison with previous floods.—The consensus of opinion is that the flood of 1903 did not equal that of 1844, volume and duration alone considered. In 1844 the rainfall was greater and the stages were from 2 to $3\frac{1}{2}$ feet higher from Kansas City to St. Louis, notwithstanding the fact that the river flowed along its natural unobstructed channel. It is thought that had the volume of the 1903 flood equaled that of 1844 the 35-foot stage at Kansas City would have been exceeded by several feet, owing to the constricted channel, with a proportionate increase at St. Louis, due both to increased rainfall and accelerated flow. As far as duration is concerned, the flood of 1844 far exceeded that of 1903. During the former year the Mississippi River at St. Louis was above the danger line of 30 feet from May 17 to July 18, inclusive, a period of sixty-three days, while in 1903 it was above the danger line for only the sixteen days from June 3 to 18, inclusive. The prolongation of the 1844 crest was due partially to increased and continuous rainfall and partially to the fact that the lower river was also at a flood stage, thereby decreasing the inclination of the flood plane, a condition not obtaining in 1903.

The flood of 1851 in the Mississippi above the mouth of the Missouri and that of 1858 in both the Missouri and Mississippi were not so extensive as that of 1844, and were of the same general character as that of 1903, except at Des Moines, where the flood of 1851 is considered to have been greater. The increased stage of the present year was due to artificial conditions, the new-made land along the banks of the Des Moines River having narrowed its channel some 200 to 300 feet, thereby considerably decreasing its carrying capacity.

Extent of damage and losses.—As has been stated before, the losses directly traceable to these floods aggregated upward of \$40,000,000, but the usual proportion between town and country losses was reversed. More frequently than otherwise the farmer has been compelled to bear the brunt of the burden, but this time the losses of the farmer were less than one-third of the total, and about the same that were borne by the rail-



Kansas City, Mo. Scene in the freight yard of the St. Louis and San Francisco Railway after subsidence of the flood.

roads, and by the owners of personal property and stocks of merchandise. In the vicinity of Kansas City alone the losses were placed at upward of \$15,000,000, while the value of county and municipal bridges destroyed was over \$750,000.

Work of the Weather Bureau.—Warnings of the coming of the floods were in all cases issued promptly, and with such detail as to stage, time, and duration as was possible. The absence of an adequate river service west of Kansas City, and the complete interruption of telegraphic and telephonic communication, prevented the forecasts in that vicinity from being of as precise a character as was to be desired. Nevertheless, general warnings of serious floods were issued promptly, and were supplemented from time to time with such other information as was obtainable. At the remaining river centers, where the service was uninterrupted, the forecasts and warnings maintained their previous high efficiency and fulfilled every required condition.

Mississippi River from Red Wing, Minn., to Prairie du Chien, Wis., by Mr. R. Q. Grant, Observer, La Crosse, Wis.—From the opening of navigation on March 21 until May 25 of the present season frequent and excessive rainfalls maintained an unusual stage of water in the upper Mississippi River. The heavy rains which fell over Minnesota and Wisconsin on May 25, 26, and 27 produced an appreciable rise at all points in the La Crosse district on the morning of May 27, and the danger-line stage of 12 feet was forecast at La Crosse.

By May 31 the crest of the rise had been reached at Red Wing, the head of the district, and continued during June 1. As the stage was only 10.3 feet, no damage occurred, the danger line being at 14 feet. At Reeds Landing, 30 miles below Red Wing, the highest stage, 9.7 feet, occurred on the same dates, with no resulting damage. On June 1 the crest stage of 11.9 feet was reached at La Crosse and maintained through June 2, after which time the water fell gradually until the end of the month.

Owing to the low-lying lands in this vicinity, and to the fact that buildings and cultivated fields have approached nearer the river than elsewhere, considerable damage to property resulted. Warnings were freely disseminated among the farmers in the threatened section, enabling them in all cases to remove stock to places of safety. This was especially necessary on the islands above the city used for pasturage, the stock in some cases being taken off in flat boats. There were, of course, no means available for the protection of meadows and cultivated fields, and it is estimated that the damage to such property aggregated \$2,000. Pettibone Park, belonging to the city of La Crosse and situated on Barrons Island, was damaged to the extent of \$100.

As no damage to buildings was anticipated no special warnings were issued to residents of the low-lying districts other than those contained in information given to the daily newspapers. Many houses in the northern portion of the city were surrounded by water, but they were constructed in anticipation of such occurrences, and consequently suffered no damage. Some timber along Black River was lost.

In that portion of the La Crosse district between La Crosse and Prairie du Chien the bottoms are not utilized to any great extent, and consequently but little damage resulted from the rise. The highest stage at Prairie du Chien, 14.6 feet, 3.4 feet below the danger line, occurred June 4 and 5.

Mississippi River from below Prairie du Chien, Wis., to Dubuque, Iowa, by Mr. Orin Parker, Observer, Dubuque, Iowa.—The river was above the danger line of 15 feet from June 3 to 9, inclusive. The maximum stage was 15.6 feet on June 6.

The water did not overflow any disputed territory in the district, and but little damage was done apart from that to island and bottom farms that are always subject to overflow when the river attains any considerable height. These lands are valuable only when the river remains low throughout the season.

The table following gives the dates and durations of the periods during which the river at Dubuque was above the danger line since the year 1875, together with the crest stage attained at each:

Began.	Ended.	Crest stage.
April 22, 1875	May 1, 1875	16.5 feet, April 26.
April 18, 1876	April 25, 1876	15.5 feet, April 20.
April 30, 1876	May 11, 1876	16.0 feet, May 6.
May 24, 1876	June 3, 1876	16.4 feet, May 28.
June 15, 1880	July 3, 1880	22.7 feet, June 23.
May 7, 1881	May 14, 1881	16.8 feet, May 10.
September 27, 1881	September 27, 1881	15.2 feet, September 27.
September 30, 1881	November 15, 1881	21.2 feet, October 25.
April 17, 1882	April 24, 1882	16.8 feet, April 20.
April 25, 1883	May 5, 1883	16.7 feet, April 28.
April 28, 1886	April 30, 1886	15.4 feet, April 29.
April 18, 1888	June 8, 1888	22.4 feet, May 13.
May 30, 1892	June 10, 1892	16.9 feet, June 1.
June 17, 1892	July 5, 1892	18.6 feet, June 24.
May 6, 1893	May 26, 1893	16.8 feet, May 12.
May 26, 1894	May 30, 1894	15.5 feet, May 28.
April 10, 1897	April 26, 1897	17.9 feet, April 15.
June 3, 1903	June 9, 1903	15.6 feet, June 6.

Mississippi River from below Dubuque to Muscatine, Iowa, by Mr. J. M. Sherier, Observer, Davenport, Iowa.—At the beginning of May, 1903, nearly normal stages of water prevailed in the Mississippi River between Dubuque and Muscatine. The ice had gone out about March 10, and the crest of the usual spring rise, due to melting snows, had passed over this reach early in April. The second rise of any consequence, which began to show at Dubuque on May 6, and which resulted in a danger-line stage at that city on May 30, was due to general precipitation, mostly in the form of snow, over the upper river basin during the last three days of April. It was augmented by rains which fell over Minnesota and Wisconsin from May 9 to 13 and over most of the upper Mississippi Valley from May 21 to June 5. On May 5 the gage reading at Dubuque was 8.9 feet; at Leclaire from May 6 to 8, 5.4 feet; at Davenport, from May 6 to 9, 7.2 feet; at Muscatine on May 9, 8.5 feet.

On the morning of May 29 the gage reading at Dubuque was 14.9 feet, only 0.1 foot below the danger line; and, as it became evident that dangerously high stages would occur at Leclaire, in the Davenport river district, the following warning was sent to that city shortly after noon: "With the present volume of water in the upper Mississippi, the river will continue to rise at Leclaire for about another week and will reach the danger line (10 feet) probably by Thursday, June, 4." On account of the continued heavy rains, the rise was somewhat more rapid than was anticipated and the danger line was passed at Leclaire on the morning of June 3, when the gage reading was 10.1 feet. On the morning of June 4 the gage showed 10.2 feet, a stage which was maintained until June 8. Though a slight falling tendency was observed on June 5, the water remained above the danger line until June 9.

Information was also distributed on May 29 to the effect that a stage of about 13.5

feet was probable at Davenport by June 6. A reading of 13.3 feet was recorded at this station on the afternoon of June 5, after which time a slight fall set in. The highest gage reading reported from Clinton was 14.6 feet, or 1.4 feet below the danger line, on June 6, 7, and 8. At Muscatine, where the danger line is also fixed at 16 feet, the highest reading was 14.65 feet, on June 6.

The damage occasioned in the Davenport district, extending from below Dubuque to Muscatine, is not thought to have been very great, the flood subsiding just as critical conditions were reached along this stretch of river. While the water was high enough to cause slight damage at a number of points, the conditions were most serious near the mouth of the Wapsipinicon River, about 25 miles above Davenport, where about 5,000 acres of agricultural lands were overflowed. About 1,500 acres of this land are used for meadows and pastures and about 3,500 acres are cultivated. At the time of the overflow crops had been planted on about 2,000 acres and these were, of course, entirely lost. Buckwheat and millet can be raised on some of the farms during the early summer months and it is thought that they can yet be planted. A conservative estimate, including the loss of labor, time, and crops places the total damage in this section at \$20,000.

At the town of Bettendorf, about 3 miles above Davenport, some very low fields were under water, but they contained no crops. The water at its highest stage was within a few inches of the doorsills of the Bettendorf Axle Company's manufacturing plant, though it did not enter any of the buildings. In the cities of Davenport, Rock Island, and Moline the damage was slight. A few cellars along the Davenport river front were flooded with seepage water and some of the poorer houses in the extreme west portion of the city were surrounded by water. On account of the very slight elevation of the land here above even ordinary water levels, the houses themselves were built high above the ground to guard against floods and thus escaped injury. The river banks on the Rock Island side were in some cases badly washed, making it necessary for the Davenport, Rock Island, and Northwestern Railway Company, whose tracks were endangered, to use several car loads of material to insure the safety of the road. At several points along this same railway between Davenport and Clinton, a rise of another foot would have resulted in much damage to the roadbed by the washing away of the ballast, especially if there had been sufficient wind to cause waves.

Much anxiety was felt at Muscatine, as the levees protecting large areas of highly cultivated lands were seriously threatened. Sand bags and cinders were used in some cases to strengthen the levees, which remained unbroken, though the water rose to within a few inches of their tops. The slough lands in the Illinois bottoms opposite the city of Muscatine were generally flooded, but they are of little importance for agricultural purposes.

Mississippi River from below Hannibal to St. Louis, and Missouri River east of Kansas City, Mo., by Mr. Edward H. Bowie, Local Forecast Official, St. Louis, Mo.—Not within the last half century have floods of the extent and destructiveness of that of June, 1903, visited the lower Missouri and upper Mississippi valleys. Having its genesis in torrential rains over Kansas, northwestern Missouri, and Iowa during the latter half of May and the first days of June, the product of persistent barometric depressions over the east slope of the Rocky Mountains and the lower Missouri Valley, the flood first threatened this district on May 30, on which day flood warnings were

issued for the Missouri River east of Kansas City. On the following day the warning for flood stages east of Kansas City was continued, and a stage of 26.0 feet forecast for Boonville and Hermann by Wednesday, June 3. On this date also the first flood warning was issued for the Mississippi River between Hannibal and Chester. It was to the effect that rapidly rising water might be expected and that the danger line of 30 feet would be reached at St. Louis by Thursday, June 4.

June 2 the following statement was made public:

"Present indications point to a stage of 34 feet by Friday on the St. Louis gage. It is yet impossible to estimate the full effect of the 35-foot stage at Kansas City, on the Mississippi River, at St. Louis, but that the 35-foot stage will be reached by Saturday or Sunday seems certain. Estimated stages for other points for Wednesday are: Hermann, 25.0 feet; Boonville, 26.0 feet; Hannibal, 19.0 feet, and Grafton, 22.5 feet."

On the day following warnings of dangerous flood stages were continued for the Missouri River at all points east of Kansas City; warnings also were issued to the effect that the rise at St. Louis and in its vicinity would continue rapid for several days, reaching a stage of 32.5 feet Thursday, 34.0 feet Friday, and 35.0 feet Saturday. Measures to protect property from a rise to 36 feet on the St. Louis gage by Monday were advised.

On June 5 the bulletin issued indicated a continued rise east of Boonville, and a rise to 37.5 feet at St. Louis by Monday or Tuesday. Saturday, June 6, the flood warning issued stated that the "crest stage of 37.5 feet forecast yesterday for Monday or Tuesday at St. Louis would certainly be reached, and measures to protect property from a stage of 37.5 to 38.0 feet should be taken." Subsequent warnings were in harmony with the foregoing forecast.

The following table shows the daily river stages and 24-hour changes from June 1 to 12, inclusive, the latter date being the one on which the fall actually set in at St. Louis.

Date.	Boonville.		Hermann.		Hannibal.		Grafton.		St. Louis.	
	Height.	Change.	Height.	Change.	Height.	Change.	Height.	Change.	Height.	Change.
June 1	22.0	+1.3	22.6	+1.6	15.6	+1.6	17.4	+1.4	27.8	+2.2
2	23.8	+1.8	23.2	+0.6	17.6	+2.0	18.5	+1.1	29.9	+2.1
3	26.0	+2.2	24.1	+0.9	20.2	+1.6	20.1	+1.6	31.2	+1.3
4	29.0	+3.0	25.5	+1.4	21.8	+1.6	21.3	+1.2	32.1	+0.9
5	30.6	+1.6	27.4	+1.9	21.4	-0.4	22.8	+1.5	33.5	+1.4
6	30.9	+0.3	29.1	+1.7	21.5	+0.1	24.1	+1.3	34.7	+1.2
7	30.2	-0.7	29.1*	-0.3	22.0	+0.5	25.8	+1.7	36.2	+1.5
8	28.8	-1.4	28.8	-0.3	22.5	+0.5	27.3	+1.5	37.3	+1.1
9	27.6	-1.2	27.8	-1.0	22.4	-0.1	28.1	+0.8	37.4	+0.1
10	26.0	-1.6	26.5	-1.3	21.9	-0.5	28.5	+0.4	37.9†	+0.5
11	23.6	-2.4	25.3	-1.2	20.9	-1.0	28.7	+0.2	37.9	0.0
12	21.4	-2.2	23.6	-1.7	20.3	-0.6	28.5	-0.2	37.7	-0.2

*Crest stage 29.5, reached during the afternoon of the 6th.

†Crest stage 38.0, reached between 6 and 8 p. m. of the 10th.

There is presented herewith, for purposes of comparison, a hydrograph of the June, 1903, flood at St. Louis, together with those of the notable floods of 1844 and 1892 for the same station. (See fig. 2.) It will be noticed that in both of the floods previous to that of the present year the length of time during which the river was above the danger line greatly exceeded that of the 1903 flood. Another remarkable feature is the rapidity of the rise and quick recession of the 1903 flood as compared with those of 1892 and 1844. The data used in the construction of the 1844 hydrograph were taken



St. Louis, Mo. Scene on the levee during height of the flood.

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from the Report of Humphreys and Abbot (Report to the Bureau of Topographical Engineers, War Department, 1861¹), and are referred to the zero of the gage now in use.

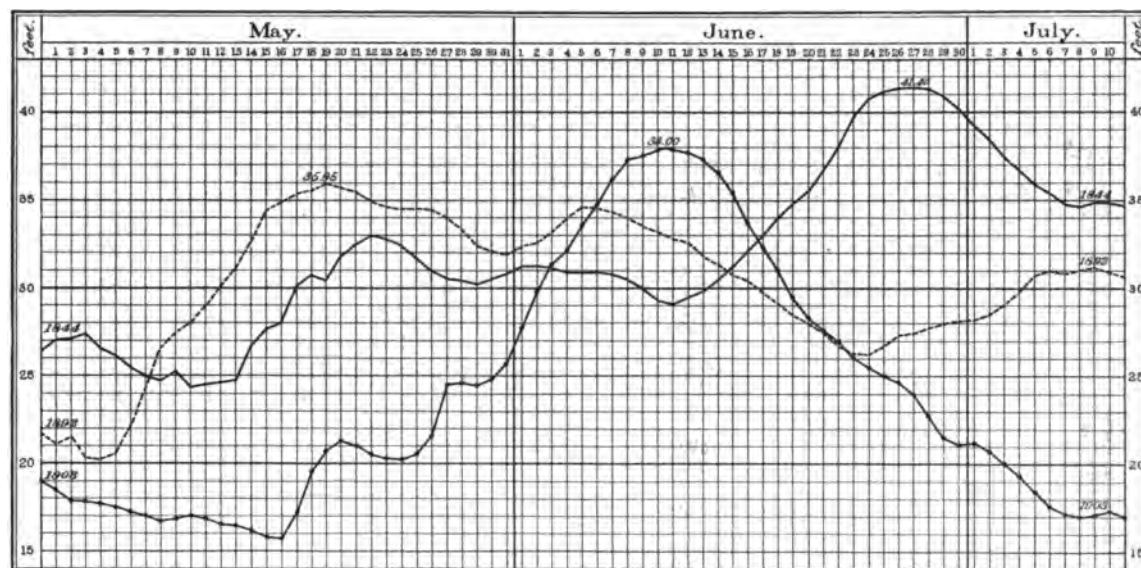


FIG. 2.—Hydrographs, Mississippi River at St. Louis, Mo., floods of 1844, 1892, and 1903.

Area inundated.—There are only minor levee systems on the Missouri River, and in time of severe flood, such as that of 1903, they serve no purpose in protecting lands from overflow. During this flood the Missouri River, from Kansas City eastward, overflowed its banks and extended from bluff to bluff, where such existed, and in places where the bluffs were distant from the river bed the width of the river was 10 to 12 miles. The total area overflowed by the flood wave in passing from Kansas City to the Mississippi River was approximately 590,000 acres, much of which is farm land under a high state of cultivation. In addition to this area the Grand River, one of the northern tributaries of the Missouri, overflowed much valuable bottom land in the northwestern portion of the State.

A large area, from Hannibal south to Grafton, was overflowed by the Mississippi River; on the Illinois side, for a portion of the distance, thousands of acres of highly productive farm land are protected from ordinary floods by the Great Sny levee, which parallels the river from below Quincy to Hamburg. This levee broke on June 5 at a point almost opposite the town of Louisiana, there being at the time 20.1 feet of water on the Louisiana gage, the highest stage since June 8, 1851, when there were 21.9 feet on the gage. Strenuous efforts had been made for several days to keep the levee intact at this place, but without avail. The crevasse was originally about 300 feet in width, but afterward increased somewhat. The usual crop damage resulted over quite a large territory, but, as the break had not been unexpected all live stock and portable property had previously been removed to places of security. The greatest overflowed district, however, was that known as the American Bottom, which extends from Alton to near Chester on the Illinois side, a distance of about 95 miles, and comprises approximately 320,000 acres of the most productive land in Illinois. With the exception of minor areas this entire region was under from 1 to 15 feet of water.

The total area overflowed from Kansas City eastward to the Mississippi, and from

¹ Report upon the Physics and Hydraulics of the Mississippi River, etc. (J. B. Lippincott & Co., Philadelphia, 1861.)

Hannibal to Chester, was about 1,200,000 acres, at least 50 per cent of which was under cultivation. The approximate area inundated by the flood wave between Hannibal and Chester is shown on Chart II.

Extent of damage.—Most unsatisfactory results have attended the efforts of the writer to secure comprehensive data on which to base an estimate of the damage from the passage of the flood in the St. Louis district, and the figures that are given hereafter can be taken only as a general approximation of the extent of the damage.

Loss of property and damage to crops, etc., in the region inundated by the Missouri east of Kansas City and the Grand River, \$3,000,000; property loss and damage to crops in bottom north of the mouth of the Illinois River, \$500,000; loss of property and crops in the American Bottom, \$2,500,000; damage to railroads in property and loss of business, \$2,500,000; damage to city property and public improvements in the St. Louis district, \$3,000,000; total damage, \$11,500,000. These figures are considered to be a very fair estimate, although some authorities placed the total loss at nearly twice \$11,000,000.

Loss of life.—Press reports have been carefully examined in order to ascertain the number of deaths directly due to the flood, and it is thought that it does not exceed 20. In East St. Louis the number of deaths reported was 17, but with the exception of 3, all were due to accidents not directly the results of the flood waters.

Value of warnings.—If the attempts to obtain accurate estimates of the total losses by the floods were comparatively unsuccessful, still more so were the efforts to obtain any correct ideas as to the value of the property saved through the Weather Bureau warnings. However, considering the timeliness of the warnings issued and the extent of property that was subject to protection, it is believed that property to the value of \$750,000 was saved through the flood warnings. The exceptionally small loss of life under such dangerous conditions is conclusive evidence as to the estimation placed upon the flood warnings. Everything possible of accomplishment was done to guard against loss of life and property during the interval of several days between the issue of the warnings and the arrival of the flood waters.

Chronological details.—May 30. Heavy rains continue over Kansas, northwestern Missouri, and Iowa, and have extended to the greater portion of Missouri. The Missouri River is rising rapidly from Kansas City to its mouth; the Mississippi River is rising slowly at St. Louis and points north. Flood warning issued at noon for the Missouri River east of Kansas City, and forecast stated that rains would continue.

May 31. Rain is again general over Iowa, Illinois, eastern Kansas, Missouri, and the lower Mississippi Valley, being excessive at a number of points in this region. The Missouri continues to rise rapidly, and at 8 a. m. had reached the danger line at Boonville and Hermann; a rise of 2.5 feet was shown at Kansas City for the past twenty-four hours. Dangerous floods forecast for all points east of Kansas City; a stage of 26.0 feet indicated for Boonville and Hermann by Wednesday, June 3. Flood warnings issued for the Mississippi River between Hannibal and St. Louis; danger-line stage indicated for St. Louis by Thursday, June 4.

Excessive rain fell at St. Louis during the afternoon. Preparations being made to protect property in the lowlands near St. Louis from high water.

June 1. The Missouri River continues to rise rapidly throughout its entire course east of Kansas City, a rise of 7.5 feet shown at Kansas City, to a stage of 35.0 feet at

that point; at Hermann and Boonville the stages were 22.6 and 22.0 feet, respectively. A rise of 2.2 feet in the twenty-four hours preceding 8 a. m. was shown at St. Louis.

The following flood warning was issued:

"The Missouri will continue to rise rapidly, and dangerous flood stages are indicated for all points east of Kansas City for several days. The Mississippi will rise rapidly in the St. Louis district, and with the water now in sight, a stage of 34 feet, or higher, is probable by the last of the week. Precautionary measures to protect property likely to be affected by such a stage should be taken. Heavy rains continue in the Missouri and central Mississippi valleys."

Heavy rain fell in St. Louis during the day. All persons and firms take precautions to protect property from overflow. Water enters the basements of houses on the levee.

June 2. The river reaches the danger line at St. Louis and continues to rise steadily. The danger line at Hannibal was passed during the twenty-four hours preceding 8 a. m., to-day. The Missouri at Kansas City shows no change in the preceding twenty-four hours from a stage of 35.0 feet. A rapid rise continues east of Kansas City. Rains continue.

The following warning was issued:

"The Missouri after reaching a stage of 35.0 feet at Kansas City to-day has since remained stationary at that point. East of Kansas City the rise will continue rapid. The Mississippi is at or above the danger line at all points in the St. Louis district; the rapid rise will continue."

The following statement was made public:

"Present indications point to a stage of 34.0 feet on the St. Louis gage by Friday. It is yet impossible to estimate the full effect of the 35-foot stage at Kansas City, on the Mississippi River at St. Louis, but that the 35-foot stage will be reached by Saturday or Sunday seems certain. Estimated stages for other points for Wednesday are: Hermann, 25.0 feet; Boonville, 26.0 feet; Hannibal, 19.0 feet, and Grafton, 22.5 feet."

Bottom lands in north St. Louis are partially submerged, as are also the lowlands on the Illinois side of the river. Extensive overflows and consequent damage reported from the Missouri River bottoms and from the region along the Mississippi south of Hannibal.

June 3. Rapidly rising water is reported from all points on the Missouri east of Kansas City. The Mississippi reaches a stage of 20.2 feet at Hannibal, 7.2 feet above the danger line for that point. At St. Louis the rise was 1.3 feet to a stage of 31.2 feet at 8 a. m. Warning issued to the effect that dangerous flood stages would prevail for several days on the Missouri and Mississippi rivers, and that a rapid rise would continue at St. Louis, reaching a stage of 32.5 feet Thursday, 34.0 feet Friday, and 35.0 feet Saturday; measures to protect property from a 36-foot stage by Monday advised. The Mississippi River completely submerged all the lowlands not protected by the railroad embankments and levees on the east side. South of St. Louis the water extends over all lowlands west of the Mobile and Ohio Railroad. All people moving out of the bottoms. Railroad companies protecting tracks on the Illinois side from overflow and levees are being guarded. The Missouri River continues to rise rapidly east of Kansas City and dangerous flood conditions now exist at all points. Reports received of extensive loss of property, but, fortunately, little loss of life indicated.

June 4. Unusually rapid rise for their present stages continues in the Missouri

and Mississippi rivers. A stage of 29.0 feet was reached at Boonville at 8 a. m., 25.5 at Hermann, 21.8 at Hannibal, and 32.1 at St. Louis. Flood warning of the 3d reiterated as regards the river at St. Louis. Higher stages forecast for the Missouri east of Kansas City and danger-line stage of 23 feet forecasted for Grafton during Friday, June 5. All possible precautions to protect property from the impending flood being taken. Lowlands for miles on the Illinois side of the river are under water. Railroads have not yet experienced difficulty in running trains east from St. Louis. Traffic in the Missouri Valley east of Kansas City has been abandoned.

June 5. River conditions and forecast:

"The Missouri has risen to 30.6 feet at Boonville and is now stationary at that point. East of Boonville the rise will continue rapid, and a crest stage of 30.5 feet may be expected at Hermann Sunday night. The Mississippi north of the mouth of Missouri is rising more slowly, owing to the numerous breaks in the levees above Hannibal, but will continue to rise, and a stage of 24 feet will be reached at Grafton by Saturday night. At St. Louis during the last twenty-four hours the Mississippi rose 1.4 feet to a stage of 33.5 feet. A stage of 35.0 feet will be reached by Saturday noon, 36.0 feet by Sunday night, and a crest stage of 37.0 to 37.5 feet by Tuesday. Measures to protect property from a stage of 37.5 feet at St. Louis should be taken."

A bad break in the levee at the West Granite pumping station was reported at midnight. The water broke through suddenly, flooding the settlement and forcing all families to flee for their lives. A small break was also reported opposite Mitchell, 10 miles north of East St. Louis. The situation on the east side is exceedingly hazardous, but thus far there has been no loss of life.

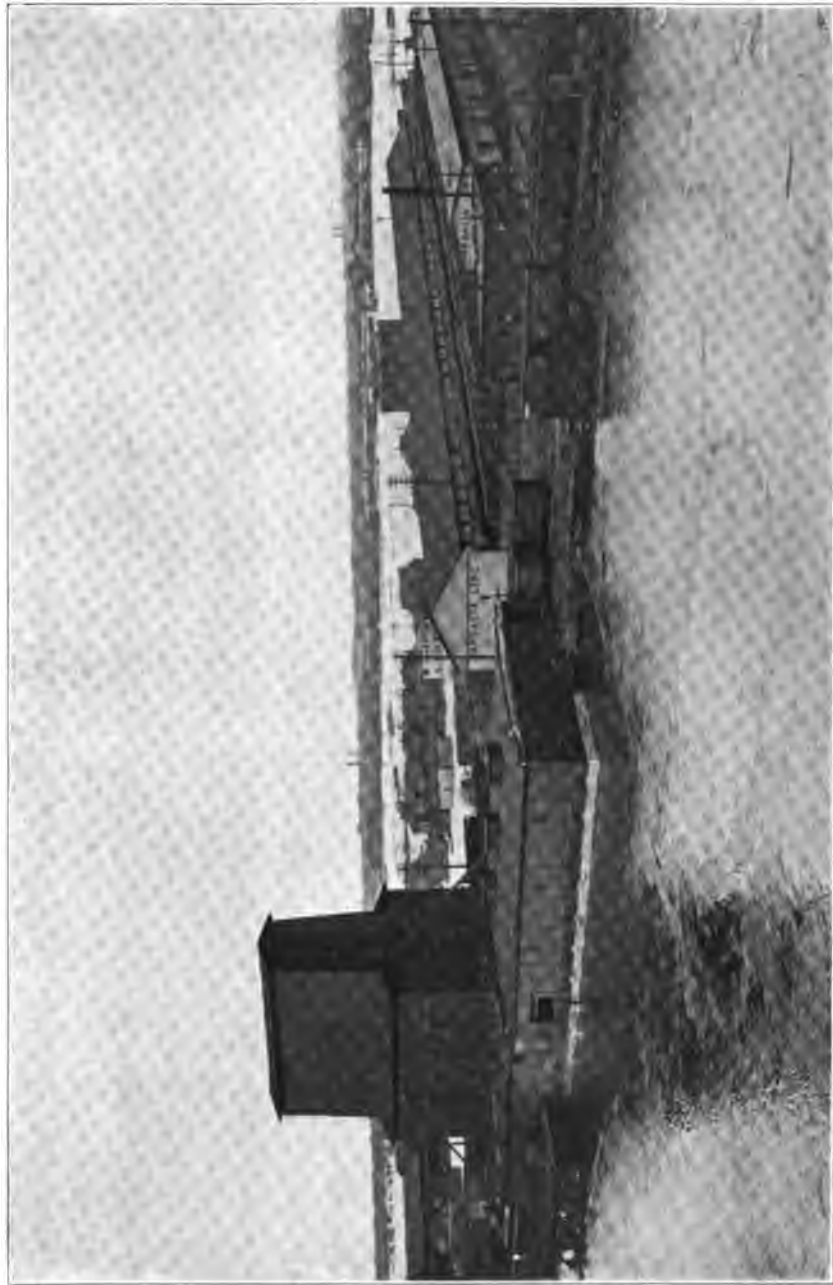
The Sny levee, opposite Louisiana, broke at 10:30 a. m., and in a short while water was rushing through a gap 300 feet long. This is the first break in this levee since July, 1888. It protects from ordinary floods approximately 100,000 acres of fine farm land. The break to-day will permit the inundation of much of this region.

Breaks occurred in the embankment of the Chicago, Peoria, and St. Louis Railroad which resulted in flooding the yards of the Wabash Railroad. Further breaks in the old levees north of East St. Louis occurred. Columbia Bottom, which occupies the peninsula between the Mississippi and Missouri rivers, to-day is one vast lake. West Alton is under from 5 to 8 feet of water. No trains running over the Alton Bridge because of breaks in railroad embankments.

North St. Louis, near the river, badly flooded, there being 5 to 7 feet of water over that section. Inhabitants of low sections in the southern part of the city were forced to move. Railway traffic demoralized and schedules disregarded.

June 6. The following bulletin was issued at 10 a. m. to-day:

"The Missouri has fallen rapidly at Kansas City; has remained stationary since noon yesterday at Boonville at a stage of 30.9 feet, and has risen 1.7 feet at Hermann to a stage of 29.1 feet. The stage of 30.5 feet forecast yesterday for Hermann will probably be reached by Sunday night. The stage of the Mississippi has not changed materially north of the mouth of the Illinois, but south of that point continues to rise steadily. A stage of 24 feet will be maintained at Grafton for several days. At St. Louis the rise will continue rapid through the next forty-eight hours, and the crest stage of 37.5 feet forecast yesterday for Monday or Tuesday appears certain of being reached; measures to protect property from a stage of 37.5 to 38.0 feet should be taken. The stage at St. Louis at 8 a. m. was 34.7 feet, a rise of 1.2 feet in the last twenty four hours."



East St. Louis, Ill. Portion of flooded district.

Hundreds of men are at work on the levees that protect Madison, Granite City, and Venice. As yet no serious breaks in the protection to these cities have occurred. In East St. Louis the levees are patrolled by armed guards. Railroads on the east side are raising the tracks, but yards are already under water, and the loss will be heavy. A number of railroad embankments on the east side gave way. Railway traffic continues utterly demoralized.

June 7. The Missouri reached a crest stage of 29.5 feet at Hermann during the afternoon. The Mississippi continues to rise slowly above the mouth of the Missouri, and below that point is rising steadily. The stage at St. Louis at 8 a. m. was 36.2 feet, a rise of 1.5 feet in the last twenty-four hours.

The Chicago and Alton Railroad embankment broke just west of the lighting plant of Granite City at 8 a. m. and at 11 a. m. a much larger break occurred near the Merchants Bridge, resulting in the flooding of a portion of East St. Louis, and the towns of Venice, Madison, West Madison, and Newport. Granite City is not altogether submerged, but Venice is under from 12 to 15 feet of water. All trains over the Merchants Bridge have been annulled as the water has undermined the approach on the east side. Conditions critical in East St. Louis, as the city is likely to be flooded from breaks in levees at any moment.

June 8. River conditions and forecast:

"The Missouri east of Kansas City and the Mississippi north of the mouth of the Missouri will fall steadily for several days. At St. Louis the stage at 8 o'clock this morning was 37.3 feet. The river at this point will remain stationary or rise very slowly through to-day and to-night and will begin to fall Tuesday. The crest stage will be between 37.5 and 38.0 feet."

Rescuers have been busily engaged in saving families from houses entirely cut off by the flood. Large numbers are brought to St. Louis and cared for by the relief corps. East St. Louis is partially submerged; Venice, Madison, Granite City, and Newport are under 15 feet of water. All railway traffic suspended, except on the St. Louis, Iron Mountain, and Southern Railroad, which runs south from St. Louis on the Missouri side of the river. The American Bottom is completely inundated by the rising waters. Business suspended in East St. Louis and all persons are engaged in strengthening levees and embankments. Loss of life is very small.

June 9. After having remained stationary throughout June 8, the river began to rise again during the night, and at 6 p. m., to-day, had reached a stage of 37.75 feet. The river forecast issued indicated falling water for the entire district north of St. Louis.

The rise in the river at St. Louis after it had remained stationary during June 8 is difficult of explanation. It is probable, however, that the brisk northerly winds that blew during the night of the 8th, and also during the 9th, were in a measure responsible for slight rise noted. The constriction in the channel at this point, produced by the numerous railroad embankments radiating from the Eads and Merchants bridges, did not permit the water to flow out under normal conditions, and the winds heaped the water to a greater height than otherwise would have been the case. This statement is apparently borne out by the fact that at the East St. Louis waterworks the water at the crest stage stood 3.9 feet higher than in 1892, when the highest water was 35.98 feet, whereas, on the gage in use by the Weather Bureau the crest stage occurring on the 10th was only 2.05 feet higher than in 1892. The East St. Louis waterworks are

located north of the Eads Bridge, while the Weather Bureau gage is located five blocks south of the same bridge, but on the west side of the river.

June 10. The rivers above St. Louis are falling at all points, except at Grafton, where the Mississippi is practically stationary. There was a slight rise on the gage at St. Louis of 0.1 foot from 8 a. m. to between 6 and 8 p. m., when a maximum stage of 38.0 feet was recorded. After this time a fall began, which increased from a scarcely imperceptible fall for the twenty-four hours immediately succeeding to a foot or more per day after the 13th.

At 1:20 a. m. water flowed over about 900 feet of the Illinois Central embankment, and flooded a large part of East St. Louis. Other breaks occurred in the Vandalia and Baltimore and Ohio embankments. East St. Louis is practically under martial law. The flood in the American Bottom is at its worst, and the rescue of persons from houses partially submerged is being carried on by means of boats sent from this city. No loss of life attended the breaking of the Illinois Central embankment, but hundreds of people were forced to leave their homes for places of safety.

June 11. The river receded 0.1 foot from 6 p. m., yesterday, to 6 p. m., to-day. All railway traffic suspended; for the past two days boats have been carrying passengers and mail from St. Louis to Alton, where trains for the East are made up and dispatched. Traffic on the lines traversing the Missouri Valley has not yet been resumed, and probably will not be for several days to come.

Review of historical floods in the St. Louis district.—The first overflow of the American Bottom, of which there is authentic record, was that of 1724. Among the archives of Kaskaskia, the ancient French capital of Illinois, is to be found a petition from the residents to the Crown of France for a grant of land. This petition was forwarded in the year 1725, and in it mention was made of the damage sustained by the flood of the preceding year. The villagers were driven to the bluffs on the opposite side of the Kaskaskia River, their gardens and cornfields destroyed, and their buildings and other property greatly injured. There are no records of the actual stages reached by the water, but the whole American Bottom was submerged, and the month was probably June.

There existed a tradition among the old French people many years since that there was an extraordinary rise of the river between 1740 and 1750; no written or printed account of it can be found.

In the year 1772 another flood came, and portions of the American Bottom were again covered. The next period of extreme high water was 1785, during which the Kaskaskia, Cahokia, and large portions of the American Bottom were submerged. Concerning this great inundation, we have but meagre information. The year 1785, however, is known in the annals of western history as "l'annee des grandes eaux," the year of the great waters. In 1844 it was contended by some of the old inhabitants of Kaskaskia and Cahokia, who remembered the great flood of 1785, that the water attained a greater height than in the last-mentioned year. It is certain that at Kaskaskia the water attained a greater height in 1844 than was reached in 1785. This assertion is not predicated upon the mere recollections of individuals, but was ascertained from existing marks of the height of the flood of that year, after the subsidence of the water of 1844. It was then proved that in 1844 the water rose 2.4 feet above the high-water mark of 1785. The destruction of property by this latter freshet was comparatively

small. The mighty stream spread over a wilderness tenanted only by wild beasts and birds, and the few inhabitants then residing within the range of its destructive sweep easily escaped to the highlands with small loss. General Edgar once said that in Kaskaskia the water rose to the surface of the door sill of the late Robert Morrison's home, but that in one place, where the court-house stood a few years since, the ground was above water. The inhabitants passed by means of water craft over the prairies and lakes from Cahokia to Kaskaskia.

There were high waters sufficient to overflow the low grounds and fill the lakes and sloughs on the American Bottom at other seasons subsequent to 1785, but none that deserve attention until that of 1811. It was in the summer preceding the "shakes," as the earthquakes were called. This flood resulted in part from the heavy rise of the Missouri River, as did the ones previously noted. In 1811 the Mississippi River commenced to rise early in May and by May 15 the water had spread over a large portion of the American Bottom. The water then began to subside, and by June 1 was over the banks only in low places, but by June 6 the water again commenced to rise, and continued to do so until June 14, when it came to a stand. At this time the greater portion of the American Bottom was under water; Kaskaskia, Cahokia, Prairie du Pont, Cantien, and nearly all remaining settlements in the bottom were inundated and the inhabitants compelled to flee to the high lands.

There was considerable destruction of property by this flood on both sides of the river, and a great many cattle were drowned. The height attained by the water has never been precisely ascertained, but it is believed that the flood was not so great as that of "*l'annee des grandes eaux*."

The flood of 1811 was much greater than any that followed until 1823, when a sudden change in the temperature after a winter of unprecedentedly heavy snowfall throughout the Northwest, and the fall of heavy rains caused the Mississippi to begin to rise rapidly about May 8. It continued its rapid rise until May 23, when it came to a stand. At that time the water entirely covered the American Bottom, and the citizens of Kaskaskia, Cahokia, Cantien, French Village, Wood River, Madison, and other settlements had been compelled sometime before to abandon their homes and seek refuge on the bluffs and in St. Louis. The houses in the lower part of St. Louis were surrounded by water. The levee was submerged, and the river rose to a height of 5 feet in the lower room of the old store at the foot of Oak street, then kept by John Shakford. The water also overflowed all the low ground about East St. Louis.

The loss of cattle was very great, and the farmers throughout the American Bottom lost heavily.

The season of 1826 was characterized by tremendous rainfalls throughout the whole Northwest, and the Mississippi was very high throughout the spring from about April 15. Toward the close of May the river had overflowed its banks and spread for miles over the country. By June 8 Cahokia, Kaskaskia, Prairie du Pont, Cantien, and the "common fields" of Ste. Genevieve were submerged, and the loss of stock and other property was very great.

Major Merrill, in the Report of the Chief of Engineers, U. S. Army, for 1872, page 429, states that the height of the water at St. Louis during this flood corresponded to a stage of 33.81 feet on present gage. The river came to a stand on June 10, and on the day following was falling rapidly.

There was also some high water in 1828, but it was not of sufficient importance to warrant special mention.

The winter of 1843-44 was not one of unusual severity, though there were tremendous snowstorms throughout the Northwest. The winter broke up early in May, but the weather continued cool and the spring was characterized by the severest rainstorms ever known in the Northwest. Early in the season the river began to rise, and by the 1st of May was full to overflowing. The population of Missouri and Illinois had greatly increased, and farming had improved the soil and largely facilitated the drainage of the land. Towns and settlements had sprung up everywhere, and along the river banks busy centers of industry had gathered and become wealthy. When they beheld the mighty rivers bank full in April they were greatly alarmed, but on May 3, when the great volume of water began to recede, all fears passed away with it. But thick clouds once more gathered, and deluges of water again poured over the face of the country. During May and June 18 inches of rain fell at St. Louis, while to the westward the fall was even greater, as shown by the records at Leavenworth. Little brooks became swollen creeks, and small creeks large rivers; little rivers became raging torrents of enormous volume, and all poured into the mighty Missouri and Mississippi their great contributions to the already overwhelming tides that rose above their restraining barriers and deluged the fairest portion of the great West.

By May 10 the river was rising again, and about a week later the situation began to create alarm at St. Louis. The Republican of May 17 calls it "a tremendous flood," and adds:

"The waters are coming down upon us from every quarter. The Mississippi is now as high as it has been known for many years and is still rising. Just above Oak street it was last evening within 6 or 8 feet of touching the curbstone. The cellars above the wharf are filling with water. It was still rising last evening at the rate of 12 inches in twenty-four hours, and this notwithstanding an immense amount is pouring over the Illinois shore. The whole of the American Bottom, from Alton to Kaskaskia, will be, we fear, submerged. The people are deserting their homes in Illinois towns."

The river continued to rise throughout May 18, 19, and 20, reaching the doors of the stores on Front street north of Pine and extending to the Pap house on the Illinois side, a distance of $2\frac{1}{2}$ miles. All the merchants on Front street had been compelled to move their stock of goods into the second stories. The waters came to a stand on May 21, with prospects of a decline, which began rapidly on May 23 and continued until the river was again within its banks on June 7. But the flood from the Missouri was yet to come, and, in addition, from June 3 to 10, inclusive, there was a continued succession of the most terrible rainstorms ever witnessed. These tremendous rains were general throughout the Northwest. The Mississippi again began to rise at St. Louis on June 8. The rise was steady, though not alarmingly rapid, but the upper Mississippi, Illinois, Missouri, Des Moines, Gasconade, Osage, Kaw, and Platte, with all their tributaries, were pouring out their floods. Slowly, steadily, yet none the less surely, the great floods from the prairies, hills, and mountains came sweeping down upon the lower valleys. Before June 12 the river was again breaking over the banks in places. Three days later the people of the valley began to take alarm and "the great flood of 1844" had commenced its devastations. There were 500 persons in St. Louis who were driven from their homes by this flood. The water covered all of

Illinoistown, now East St. Louis, rose above the first stories of the houses, and reached to within a few inches of the height attained in the freshets of 1823 and 1826. A considerable portion of the curbstones on Water street were covered and the water was running into the lower stories of the houses of Battle Row, corner of Laurel street.

All the rivers above were reported to be rising, but the principal rise was from the Missouri, the so-called "June rise" from the mountains. The Missouri, the upper Mississippi, and the Illinois, and their tributaries, were overflowing their banks and rising rapidly, spreading destruction and consternation among the inhabitants of the bottoms, whose losses were very great. Many of the farms were completely under water, their crops entirely destroyed, and the stock either carried away by the flood or scattered over the country.

The Illinois River was within 6 inches of the high-water mark of the great flood that had occurred seventeen years before, and at Naples it had overflowed the banks and filled the streets with water.

On June 17 the river was about 6 inches higher at St. Louis than the high-water mark of the month before. North of Locust street, on Front street, and above Vine street the water rose over the sidewalks and into many of the stores, forcing the merchants to carry their damageable goods into the second stories, and to place others on shelves and counters. The next day the steamer *Missouri Mail* brought the alarming news of a great rise in the Missouri River, which, on June 13, was rising at St. Joseph at the rate of 7 feet in twenty-four hours.

The whole country between Weston and Glasgow was under water. Camden Bottom was covered to a depth of 6 to 8 feet, and the officers of the *Mail* spent much time in relieving those who were in danger.

On Thursday, June 20, the Mississippi was from 3 to 6, and in many places 9 miles wide. It covered all of Front street and the sidewalk. The steamer *Lightner* was resting her bow against the front of Henry N. Davis's store at the corner of Front and Morgan streets. The water was up along Battle Row nearly to the door hatches. At the corner of Pine and Front streets the water was midway on the doors. The lower part of the city, in the vicinity of Mill Creek, was entirely submerged, and below the bridge the water covered Second street. On the Illinois side everything was under water; at Cahokia the inhabitants were forced to flee to the bluffs, and several houses in Illinoistown were moved from their foundations, some being overturned.

About 12 o'clock, on June 22, the city engineer ascertained that the water was 3.3 feet over the city directrix, the curbstone on Front street east of the market house. From 7:30 Thursday morning, June 20, until 7:30 Friday evening, June 21, the rise was 1.4 feet. This was an enormous and unparalleled rise, and can only be properly comprehended when the whole width of the river is considered. In many places it was from 10 to 15 miles wide. For the twenty-four hours of Sunday, June 23, there was a rise of 1.2 feet, but the climax had about been reached, although there was a further slight rise until June 28, when a stage of 41.39 feet was recorded. The waters then began to recede, and by the middle of July had fallen to the usual level.

The long-continued and ruinous flood of 1851 did not attract particular attention until "fearful accounts of the rise in the upper Mississippi," the river being over its banks in many places, reached the St. Louis newspapers of May 29, 1851. Two days after the river began to rise rapidly at St. Louis, and by sunset of May 30 was 15.7 feet

below the high-water mark of 1844, as marked on the column in front of the Center Market, and 8 feet below the city directrix or the curbstone at the corner of Market street and the levee. A large portion of Duncans Island, 7 houses, and a portion of the dike erected by the city between the island and the Illinois shore were washed away. The river continued to rise at St. Louis until June 10, when it had risen to within 4.8 feet of the high-water mark of 1844. After this date the water began to decline. The desolation that visited the States watered by the Mississippi, the Missouri, the Illinois, and their tributaries was beyond all calculation.

In 1855 the river was very high, the water entirely submerging the levee at St. Louis. Great damage was done, especially in the lower course of the river.

In 1858 the water rose to a point within about 4.2 feet of the flood of 1844. Many towns were inundated, and vast destruction of property effected. In 1862 the flood rose high and swept away much property. The water came into stores on the levee at St. Louis. This was the last great flood until 1881, though the water rose quite high in 1867 and again in 1876. The flood of 1881 began in May, and on the 4th day of that month, from the foot of Anna street, on the St. Louis side, the only limits for the water were the bluffs, 3 miles to the eastward. East Carondelet, as the little village opposite Carondelet is called, was flooded by the breaking of the dike at the head of the island, and the inhabitants were compelled to seek safety on the high grounds.

Floods also prevailed in June, 1883, when a stage of 34.8 feet was observed at St. Louis and again in 1892, when the water on the St. Louis gage was the highest since 1858. The water this year flooded the entire American Bottom and the towns situated therein. The Illinois River was also unusually high this year. Heavy damage resulted in this vicinity, and railway traffic was almost entirely suspended.

Many of the above facts were gathered from the records on file with the Missouri Historical Society and from the Report of Humphreys and Abbot to the Bureau of Topographical Engineers, War Department, 1861, referred to on page 37.

Mississippi River from below Muscatine, Iowa, to above Hannibal, Mo., by Mr. F. Z. Gosewisch, Observer, Keokuk, Iowa.—At the close of the winter the soil in the Mississippi and Des Moines valleys was reported to be in an exceedingly moist condition to a considerable depth. The same conditions were observed at the close of the winter of 1896-97, when, in the monthly report for January, 1897, attention was invited to the fact, and the disastrous flood of 1897 followed. As early as February of the present year the attention of interested parties was frequently turned to these conditions, and the opinion expressed that high water might be expected during this season. Springs with much greater rainfall in this drainage district have not shown unusually high water, and longer and more thorough investigations are necessary in order to establish the correctness, or otherwise, of the opinion that the previous soil conditions were directly responsible for this, and other floods.

The data available for predicting river conditions at this station consist of the morning reports from Galland, Davenport, La Crosse, St. Paul, Des Moines, and Ottumwa when the Des Moines River conditions are threatening. On May 27 the official in charge at Des Moines telegraphed that the Des Moines River was rising rapidly at that point, and special reports were at once called for from Ottumwa. The Mississippi was then 10.9 feet at Keokuk, not an unusually high stage for the season. On Thursday, May 28, reports showed the Des Moines was still rising rapidly, with a

slow rise in the Mississippi at Galland and Davenport, and these conditions seemed to warrant the following warning that was then telegraphed to Burlington, Wever, Fort Madison, Warsaw, Quincy, Alexandria, Gregory, Canton, and Lagrange:

"The Mississippi and Des Moines will continue rising. The Mississippi will probably reach the danger line between Burlington and Hannibal by Sunday night."

The Mississippi passed the danger line (15 feet) during Sunday, May 31, at Keokuk, and during Sunday night the Des Moines River broke the Egyptian levee, which extends along its south bank, flooding the lowlands lying between the Des Moines, Mississippi, and Fox rivers. The break was 12 miles west of the mouth of the Des Moines. On the Illinois shore the lowlands are protected by a chain of levees, the first being the Hunt levee, which begins immediately south of Warsaw. It joins the Lima Lake levee, which extends from near Lima Lake southward to Bear Creek, and thence westward along the north bank of Bear Creek to the bluff line. Next follows the Indian Grave levee, which extends along the south bank of Bear Creek to the Mississippi, and thence southward along the Mississippi to near Quincy.

Daily inquiries were received from Warsaw and Alexandria over the telephone lines regarding the river conditions, the mail arrangements with these points being such that river bulletins can not reach them until late in the evening. Working parties made every effort to save the Illinois levees, the United States Engineer Corps going to their assistance with steamers and barges.

On June 3 the following bulletin was published and given to the press:

"The Des Moines River is falling along its entire length, but is held stationary at its mouth by the flood in the Mississippi. The latter river continues to rise slowly north of Keokuk, and the flood coming from the Missouri will check any rapid fall of the Mississippi to the southward. The indications point to a slow rise for several days."

During the night of June 3 breaks occurred in each of the Illinois levees, and the water at Alexandria is reported to have been 6 inches higher than the high-water mark of 1851, the highest previous record. However, the situation was slightly relieved by the breaking of the Illinois levees. On the evening of June 4 Galland reported a stage of 10 feet, which was the first authentic information received that the Iowa, Cedar, and Skunk rivers must be at a flood stage, no reports having been received from either of these streams. The following bulletin was given to the press:

"Flood waters are now entering the Mississippi from the Iowa, Cedar, and Skunk rivers, and the Mississippi will not reach its highest stage for several days."

The Mississippi reached its highest point at Keokuk about midnight of June 5, the gage at that time reading 19.55 feet, only 0.05 of a foot lower than during the flood of 1897.

On the morning of June 6 the following message was telegraphed to river points between Burlington and Quincy:

"The flood has reached its height at Keokuk, and the upper Mississippi will fall slowly."

A steady decline of from 0.5 to 0.7 of a foot per day then began, and by the morning of June 14 the river had once more fallen below the danger line at Keokuk.

The area flooded by the breaking of the Illinois levees between Warsaw and Quincy is 35 miles in length, with an average width of 4 miles, and consists mostly of rich farm lands. The damage in this district is estimated at \$250,000.

Mr. Charles Albers, of Warsaw, in a letter dated June 21, 1903, says:

"We sent out messengers on horseback upon receipt of your warning and saved all who heeded it. Some could not realize its importance and would not believe it possible that the water could rise so high. The flood found these entirely unprepared and they escaped only through the assistance of others. Many thanks for your reports which saved much greater loss."

No regular levee system exists on the Missouri shore, although lands between Alexandria and West Quincy are partially protected in some places by small levees which extend for short distances only.

Mr. W. N. Sage, of Alexandria, in a letter dated June 27, 1903, says:

"I want to thank you in behalf of our citizens and myself for your services in giving us the flood reports during the recent flood, and more especially for your telegram of May 28, which was the means of saving a large amount of property. It is difficult to estimate just how much was saved, but there was a great deal of stock taken to the uplands, which would have suffered had we not received that message."

On June 4 a levee that extends along the south bank of Skunk River, and protects a rich bottom lying between the Skunk and Mississippi rivers, broke at a point 8 miles from the mouth of Skunk River, near the bluff line, flooding 14,000 acres of land mostly in crops.

Mr. Joe Frey, of Wever, in a letter dated June 22, 1903, says:

"Your warning was the means of saving between \$2,000 and \$3,000. I, personally, carried the telegram to 15 families, and then sent it across the river to Dallas City, where it was carried to points up the river."

Information as to other localities was derived entirely from newspaper reports. These stated that the lowlands in Illinois opposite Burlington were flooded to a distance of from 4 to 8 miles, and that a large tract lying between the Mississippi and the Cedar rivers was overflowed.

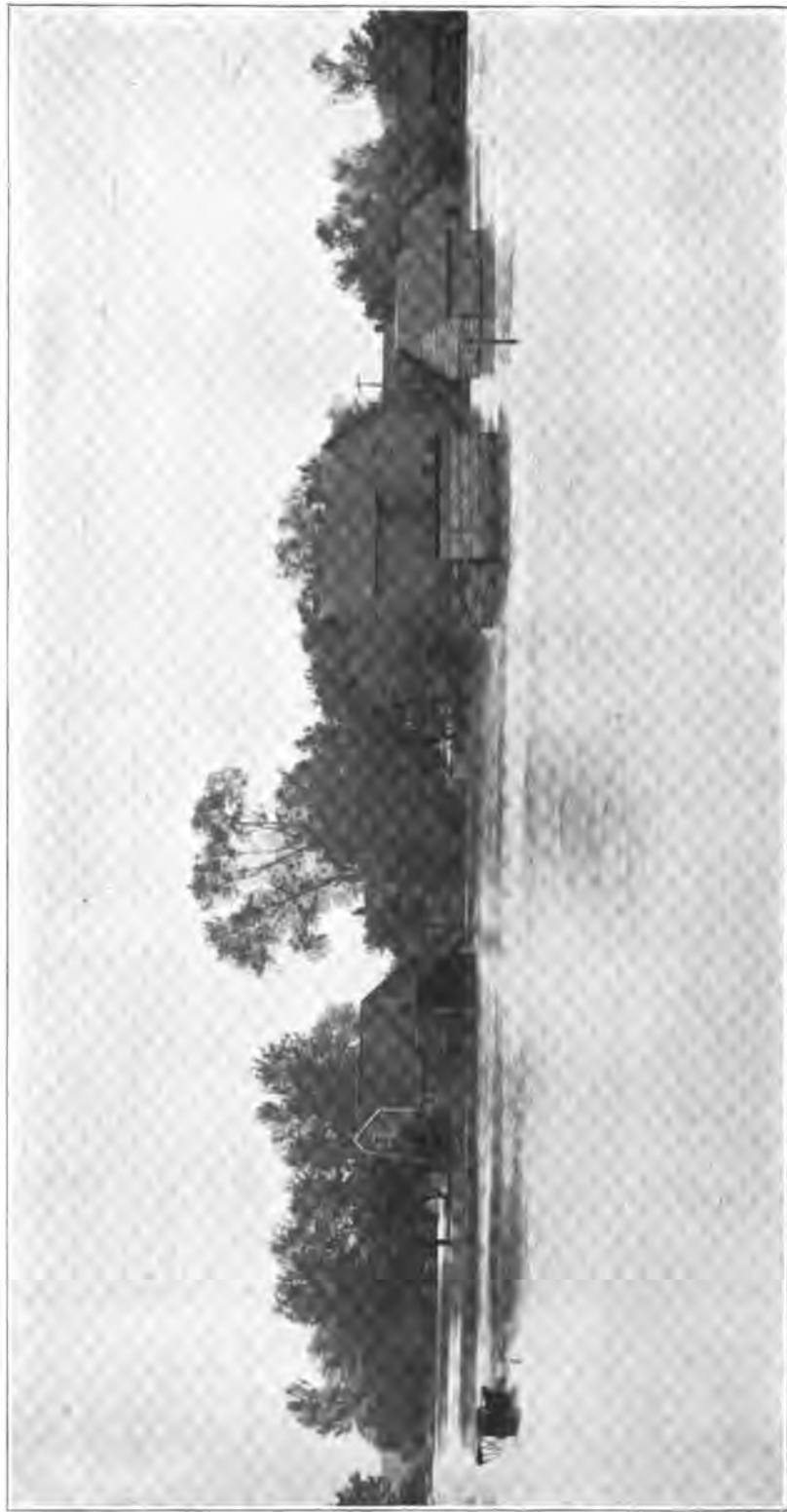
The levee at New Boston was threatened, but by timely work was kept intact.

Des Moines reported a stage of 23.5 feet on May 31, exceeding by 2.5 feet the previous high-water mark of July 10, 1902, while Ottumwa on June 1 reported 22.0 feet, 4.1 feet above the previous high-water mark of accepted record, that of July 14, 1902. Towns along the entire length of the Des Moines River reported that the water rose from 1 to 3 feet above the accepted high-water marks of 1851.

By June 1 all lowlands, both in towns and in the country, along the entire length of the Des Moines River, from Des Moines to its mouth, were flooded and the railway bridge at Bentonsport was carried out by the flood.

All trains running south from Keokuk were abandoned on June 1, and the railroads, consisting of the Chicago, Burlington, and Quincy; the Keokuk and Western; and the Chicago, Rock Island, and Pacific could not resume service until after June 14. Beside the loss in traffic, these railways estimate their damage to roadbed and equipment at \$150,000.

Owing to timely warning the loss of stock has been trifling, and I have been unable to find a single instance of loss of human life. Small grains and meadows have been a total loss, but over the largest flooded areas corn lands only were overflowed, entailing only a loss of seed and what labor had been expended in planting. These lands have been already replanted with a fair prospect of a bountiful crop, as the floods have enriched them with from 8 to 10 inches of deposit.



Des Moines, Iowa. Portion of flooded district in south Des Moines.

Des Moines River at Des Moines, Iowa, and vicinity, by Mr. Geo. M. Chappel, Section Director, Des Moines, Iowa.—The basin of the Des Moines River extends from southern Minnesota southeastward to the southeast corner of Iowa. It is quite narrow in the southern portion, but is about the width of three counties in its middle and upper portions, and has an area of about 6,000 square miles north of Des Moines. The river rises in several small streams in southern Minnesota and northern Iowa. The two principal branches or forks are confluent in the southern part of Humboldt County, south of which point many tributaries flow in the main stream. The principal one on the east side is the Boone River, which has its junction in Webster County, and the principal one on the west side is the Raccoon, or "Coon," as it is commonly called, which unites with the Des Moines in the southern portion of the city of Des Moines.

In its northern portion the river flows through a flat or gently rolling country, with wide and shallow valleys in which there are many lakes and ponds, some of them quite large. There is a difference of about 500 feet in elevation between its source and Des Moines, a distance of about 200 miles.

Over the whole of the Des Moines Valley the ponds, sloughs, creeks, and lakes have been filled with water since last summer and the soil became thoroughly saturated with moisture. Many of the fields in the northern portion of the State were converted into veritable lakes by the heavy rains of the past season, and were not drained off before freezing weather set in last fall. Consequently, there was a superabundance of water on and in the ground at the time the spring of 1903 opened, notwithstanding the fact that the rainfall during the winter and early spring months was below the normal amount.

During the month of May showers were general from the 2d to the 5th, inclusive; from the 9th to the 13th, inclusive, and from the 17th to the close of the month. There are 17 meteorological stations in the Des Moines and Coon valleys, north of Des Moines, and including the record of the central station, there was an average of 2.36 inches of rainfall in the upper river basin between May 2 and 15, and 7.51 inches between May 17 and 31, making an average for the 18 stations of 9.87 inches during the month, nearly all of which found its way into the rivers and passed through this city. The showers on May 25, 26, and 27 were heavy at all stations and excessive at several; the largest 3-day rainfalls were 4.89, 4.69 and 4.63, respectively, and a number of other stations reported amounts exceeding 3 inches for the same period.

In studying the rainfall for the month and its effect on the stage of the water in the river, it is found that, although the precipitation was light during the first half of the month, it caused a rise of 6 feet on the gage between the 11th and 16th days, conclusive evidence that the soil and all water courses were saturated at the time the rain began, and that practically all the new supply of water found its way into the rivers. In comparing conditions existing this year with those of 1902 we find a decided difference. In 1902 rain began falling on April 25, and was almost a daily occurrence during May, June, and July; yet little change was noted in the stage of the river until July 6, at which time the gage read 7.2 feet. The water was then rising rapidly, reaching a stage of 21 feet on July 10. The summer of 1901 was extremely dry and by the close of that year many wells and most all sloughs and creeks were dry, with but little water flowing through the rivers. The stage of the river at this station during that summer averaged less than 4 feet, and the channel was but a few feet wide.

The fact that in 1902 it required nearly three months of abnormally heavy rainfall to saturate the soil and fill the wells and creeks is, in our opinion, another evidence that the soil of this treeless region possesses wonderful capacity for storing and retaining moisture.

At the morning observation on May 25, 1903, the river gage read 9.5 feet, a rise of 0.5 of a foot during the preceding twenty-four hours. Warnings were at once issued of a decided rise within the next three days.

On May 26, at 8 a. m., the gage read 10.0 feet, with indications of a rapid rise in the near future. As there was no way of obtaining authentic reports from the upper valley, a special request was sent 12 voluntary observers located in that section to forward to this office daily reports of rainfall and, if possible, the stage of the river in their respective localities. The police department was requested to direct all officers patrolling the sections of the city near the rivers to notify all people to prepare for the flood and to remove all movable property, as the water would probably be as high, or higher, than it was in 1902. The operators at the telephone exchanges were also kept advised as to the conditions and prospects. Watchmen were placed by the people along the levees to watch the rapidly rising river and give notice of approaching danger. In many stores and manufacturing houses the employees and extra forces of men were busily engaged in removing every thing of a movable character to places of safety and to protect such articles as could not be moved.

On May 27 the gage read 13.5 feet at 8 a. m. and 15.8 feet at 6.15 p. m. Railroad train service began to feel the effect of the continuous rains and high water on the roadbeds, bridges, and culverts. Every train in or out of the city was from a few minutes to several hours late, and service on the Chicago, Milwaukee, and St. Paul Railroad was suspended for the twenty hours preceding the evening of May 26; the Chicago, Rock Island, and Pacific Railroad did no business on its Ruthven branch for twelve hours, due to a washout 2 miles west of Rippey. Trains from the north on the Chicago Great Western were six hours late on account of a washout at Dunkerton, and the trains from the south were also late on account of soft roadbeds.

On May 28 the gage read 18.7 feet at 8 a. m., 19.8 feet at 12:45 p. m., 20.2 feet at 2:30 p. m., and 21.0 feet at 7 p. m., which equalled the high-water mark of the 1902 flood. Strenuous efforts were made to protect and reinforce the dikes along the river fronts, but in spite of all that could be done the water would seep through, softening and washing the banks.

The bottom lands north of the river, from the Flint Brick Company's yards eastward to Union Park, were flooded early in the day. The water was from 2 to 3 feet deep over the pavement on north Sixth avenue. Crocker Park was also flooded. The whole of Central place, situated east of the Highland Park car line, and the tract between the Natatorium and North street, were inundated during the afternoon. All of that portion of southeast Des Moines, east of Fourteenth street and south of the Burlington tracks, was flooded.

The bottom lands along the Coon River were under water as far east as Eleventh street; from the Rock Island tracks on the north to the bluffs on the south side of the river, and from Fifth street eastward to the Des Moines River and south of Elm street.

Briefly stated, the casualties for the day were as follows: Two spans of the Melan

Arch Bridge on north Sixth avenue were carried away, one in the morning and one in the afternoon. Water seeped through the banks at the street car power plant and entered the engine room, necessitating a suspension of all street car service for several hours in the afternoon. Twenty families were driven from their homes in Central place, as were also 200 families in southeast Des Moines, in the packing house district, east of Fourteenth street, and 50 families from southeast west Des Moines, between First and Fifth streets and Elm street and the Coon River. The ice houses belonging to the Des Moines Ice Company on the north side of the Des Moines River, near the Sixth Avenue Bridge, and one house belonging to the Diamond Ice Company, were carried away with their contents. The Edison Electric Light plant on the west bank of the Des Moines, above Grand avenue, the Capital City Gas plant on the east bank, below Vine street, and the Des Moines Waterworks Pumping plant on the north side of the Coon, near the Eighteenth Street Bridge, were all in danger of being flooded, and energetic efforts were made to strengthen the banks near-by by the use of gravel, baled hay, and bags of sand. The gas company used bags of Portland cement.

On May 29 the gage read 21.0 feet at 8 a. m. The banks and bridge piers indicated that the water had been up to about 21.3 feet during the night. There was but little change in the stage of water until evening, when it began rising again.

The dikes which protected the manufacturing districts, located between Fifth and Eleventh streets and south of the Rock Island tracks, gave way at 11 p. m., and the whole section was flooded, necessitating a cessation of all business.

At the close of the day the flooded district included all of the bottom lands on the north side of the Des Moines River from the Flint Brick yards to Union Park, and on the south side from Douglas Park to Crocker Park; all of Central place from the river westward to the foot of the hill; a square west of the Highland Park car line, and from the Natatorium southward to below North street; and all of southeast Des Moines south of the Burlington tracks. The Coon River was out of its banks from Valley Junction eastward to the Des Moines River, and the water extended from the foot of the hills on the south side to the Rock Island tracks west of Eleventh street; from Eleventh street eastward, and also south of Elm street. A large portion of south Des Moines was under water, the dikes constructed by the Clifton Heights Land Company being the last to give away. The water began to wash over the east end of the Center street dam and across the approaches on the east end of the Grand avenue and Locust street bridges. All railroads discontinued the use of their bridges as a precaution against possible accident.

The street car power plant was so badly crippled that it was impossible to keep more than one car running on each line.

All laboring men who could be employed were given work on the embankments protecting the electric light and gas plants. Seven ice houses and their contents were carried away.

May 30 the gage read 22.5 feet at 8 a. m. The heavy rain which began at 10:30 a. m. on May 29 continued until evening, but from the best information obtainable it is not believed that heavy rains extended north of the main line of the Chicago and Northwestern Railway.

In spite of the strenuous efforts made to reinforce the dikes protecting the main portion of southeast Des Moines the water broke through at 3 a. m., and at about the

same time began running over the banks between the east end of the Center Street Bridge and the tile works, flooding that portion of east Des Moines which lies between the river and Fourth street, and from the street car power plant southward along the Northwestern tracks to the Rock Island right of way; thence eastward along the Rock Island tracks which skirt the foot of the hills as far as eye could reach. All bottom lands on both sides of the Des Moines and Coon rivers were flooded. It is estimated that between 8 and 9 square miles of territory within the city limits were under water. The river continued to rise slowly but steadily all day, and reached the high-water mark of 23.5 feet in the evening. This record exceeds that of 1851, the highest previously known, by 1.0 foot, but it is not believed that the volume of water was as great this year as in 1851, when the river channel was 200 to 300 feet wider. Much new land has been made along the banks of the river between the Center street dam and the Coon River junction, and the bottoms on the east side have been filled in from 4 to 5 feet between the river and east Sixth street.

A steam fire engine with a detachment of firemen arrived from Chicago to assist in pumping out the seepage water around the waterworks pumping station and to fight fire in case the waterworks were compelled to shut down. The water was so deep in the street car power house that it was necessary to discontinue all car service. No railroad trains arrived or departed from the city except on the Chicago and Northwestern Railway, and the trains on that road started from Capitol Park. Passengers and baggage from the west side were transferred in boats from the east end of the bridges, and by wagon to and from the depot to Capitol Park.

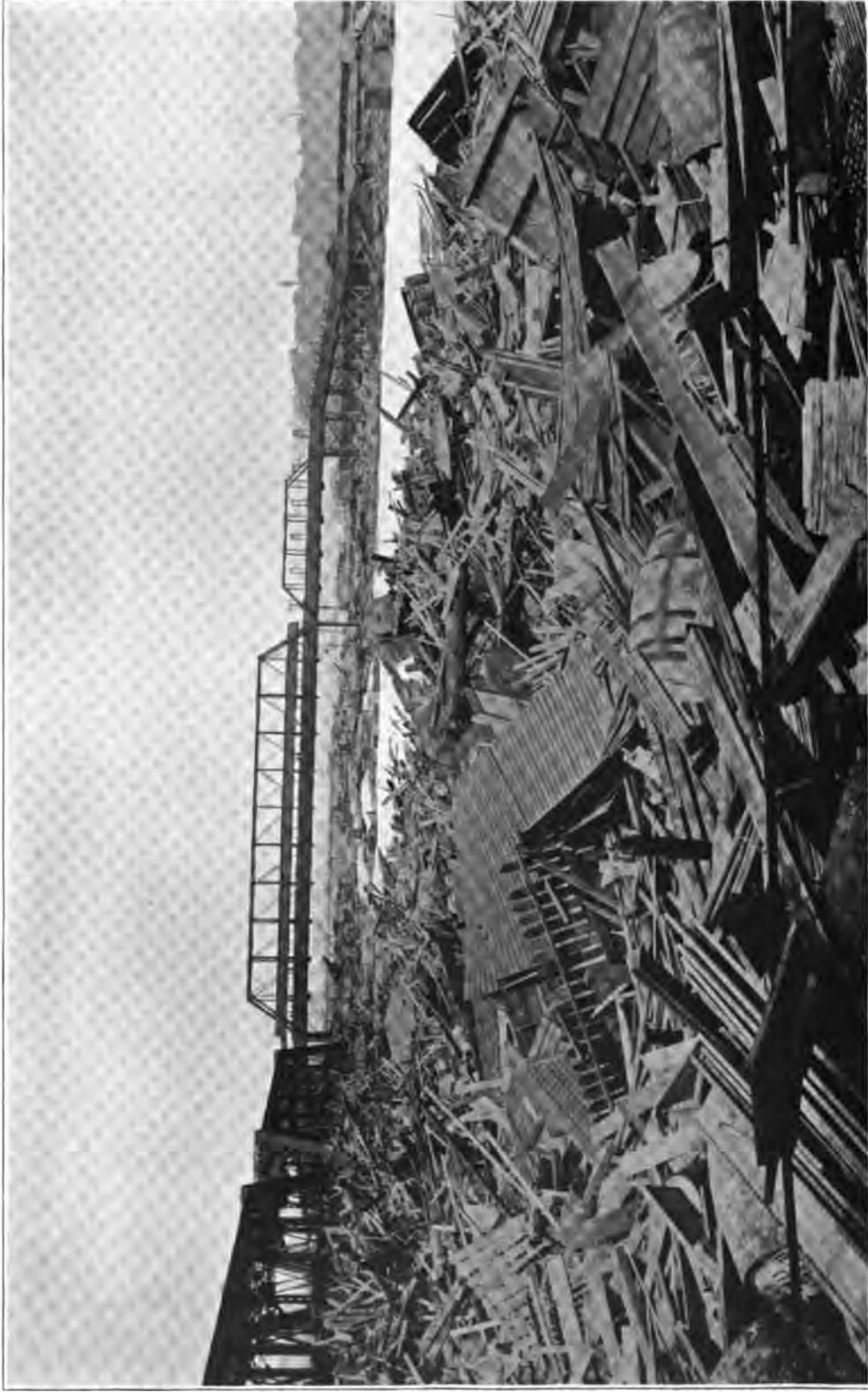
Great fears were entertained that the city would be in darkness on account of the water reaching the electric light and gas plants, but it was kept out by the use of baled hay, bags of sand, and clay. The gas company used hundreds of bags of Portland cement, making a solid wall around their plant.

On May 31 the gage read 23.5 feet at 8 a. m., about which time the water began to recede, to the great relief of all. The water continued to recede steadily during the two following weeks. The gage readings at the morning observations were as follows: June 1, 21.0 feet; 2, 19.2 feet; 3, 17.6 feet; 4, 16.5 feet; 5, 15.4 feet; 6, 14.5 feet; 18, 6.2 feet.

Street car and railroad services were resumed on June 1, but trains were late in arriving for several days and the street car company stated that it would be impossible for them to have all cars running on the usual schedule time before the end of June.

Loss of and damage to property is estimated to be about \$500,000, and 4,000 people were driven from their homes during the flood. There were several accidents which resulted in the loss of 4 lives, but from the best information obtainable there were no lives lost as a direct result of the high water.

Before closing this report I wish to express my appreciation of the valuable assistance and information furnished this office by the local officials of the Chicago, Rock Island, and Pacific Railway, the Chicago, Milwaukee, and St. Paul Railway, the Chicago and Northwestern Railway, the Iowa Telephone Company, the twelve voluntary observers who rendered special reports, and the city engineer and his assistant. The railway and telephone officials obtained and gave us reports of the stage of the rivers at their stations above Des Moines; the voluntary observers rendered daily reports of rainfall and the condition of streams in their respective vicinities; while the city engineer



Kansas City, Mo. Flood debris, Kansas River; Missouri Pacific Railroad bridge on the left.

and his assistant located on a map of the city the various levees, and traced the high-water line in all sections of the city.

Mississippi River at Hannibal, Mo., and vicinity, by Mr. L. C. Cover, Observer, Hannibal, Mo.—Heavy and practically continuous rains over the watersheds of the Snake, Skunk, Des Moines, and Mississippi rivers during the last ten days of May and early in June, resulted in a flood which surpassed all previous records for high water in this vicinity. At Hannibal the danger line of 13 feet was reached on May 29, and a maximum stage of 22.54 feet on June 8, about three-quarters of a foot higher than the previous high-water mark of June 7, 1851. On June 7, 1903, the stage was 22 feet, but 0.2 of a foot higher than it had been on exactly the same day fifty-two years previous. After June 8 the river began to slowly subside, and on June 21 it again fell below the danger line.

On May 27 warnings were issued to the railroad companies, levee commissioners, farmers, and residents of the islands and lowlands of a probable stage of 15 feet. Further warnings were issued daily, giving notice of coming higher stages, and the inhabitants of the districts threatened by overflow were enabled to move all portable property to places of safety.

The estimated loss from the high water southward from Quincy to and including Hannibal, amounts to about \$365,000, distributed as follows:

Crops, houses, and farm implements.....	\$100,000
Railroad losses, Quincy to Hannibal.....	150,000
Hannibal industries and property.....	50,000
Salary losses for about ten days as a result of closing factories, mills, shops, etc.....	50,000
Creve Cœur Lake Company's houses and ice.....	15,000
Total	\$365,000

Five lives were lost as a result of the high water—4 when the steamer *Flying Eagle* was wrecked at the bridge on June 3, and 1 when a man was drowned on June 1 while removing stock from Bay Island. This island, which is just north of Hannibal, contains 11,300 acres that are subject to complete overflow at a 17-foot stage on the Hannibal gage, and of these, 8,000 acres are under cultivation. On the Missouri side of the river, from opposite Quincy southward to Hannibal, there are about 18,000 acres subject to overflow, 10,000 of which are under cultivation, while on the Illinois side there are 8,620 acres between Quincy and the Sny levee that are subject to overflow, and practically all of it is under cultivation.

Within the city of Hannibal the flood waters extended over about all of south Hannibal, which is below Bear Creek, and comprises the lumber and manufacturing district; the lumber yards on the north side of Bear Creek, the railroad yards, and the two blocks nearest the river in the northern portion of the city.

Missouri River from mouth of Platte River to Kansas City—Kansas River, by Mr. P. Connor, Local Forecast Official, Kansas City, Mo.—The flood of 1903 marks an epoch in the history of Kansas City. It came at a period of unusual business activity and great commercial prosperity. Vast industrial schemes were being projected, and important economic problems between capital and labor were nearing a crisis.

Such a flood had never before been experienced in this section, except by the very few pioneers who witnessed the historic flood of 1844. No wonder that people were reluctant to leave their homes, or to avail themselves of timely advice to save their effects until too late. Bound by the ties of affection for the old home, thousands waited until

the last perilous moment, and 19 are known to have been borne to destruction by the seething waters. It seems miraculous that the number was not twenty times as great.

While the devastation was appalling at many places along the Kansas River, it was at this place that it reached the climax of its destruction, and made history which may not be repeated within the life of the present generation.

The stage reached was just 2 feet below the recorded stage of the 1844 flood, which had been heretofore disputed and discredited by a great many people. It is doubtful if its accuracy will ever again be questioned, for had the rains continued two days longer the river would have made a new record exceeding anything for at least one hundred and fifty years past.

This flood was entirely due to the frequent and excessive rains of May over the Kansas River basin, slightly augmented by similar conditions over the extreme southwestern counties of Iowa and the extreme northwestern counties of Missouri.

The drainage area of the Kansas River comprises about 36,000 square miles in the State of Kansas, practically the northern half of the State; 11,000 square miles in Nebraska; and about 6,000 square miles in Colorado; making a total of 53,000 square miles.

The Nebraska portion is drained by the Republican and Smoky Hill rivers. The Smoky Hill receives the Saline River at New Cambria, and the Solomon, which drains the northwest portion of the State, at Solomon, about 15 or 18 miles farther east. Later it unites with the Republican at Junction City, to form the Kansas, or, as it is popularly known, the Kaw River. The Big Blue rises in southeastern Nebraska and joins the Kaw at Manhattan, 160 miles west of Kansas City.

The auxiliary territory contributing to the flood comprised about 6,000 square miles in Iowa and 2,700 in Missouri, drained by the Nishnabotna, Nodaway, and Platte rivers.

The rainfall during the month of May was from 1.75 to 3.00 inches in excess of the normal amount in the western third of the Kansas basin, and from 7 to 8 inches in excess in the central and eastern thirds.

During the last eleven days of the month the enormous quantity of nearly 7 inches of rain fell in the central and eastern thirds, not scattered downpours, but general rains which had to be carried off by the already surcharged rivers and creeks. Similar conditions obtained over the Iowa and Missouri territory referred to, the Nishnabotna and Nodaway, emptying into the Missouri a short distance above St. Joseph, and the Platte River of Missouri merging into the Missouri below Leavenworth.

As at Plattsmouth low stages were reported during May, the range of readings being only about 6 feet, a sharp line can be placed on the northern limits of the flood-producing area.

Flood damage began in Kansas and southeast Nebraska on May 26, possibly at the close of May 25; at Kansas City May 29 and along the Missouri May 30.

A preparatory warning was issued from this office on May 26 to the effect that, should the excessive rains continue, the river would reach the danger line at Kansas City in a few days.

On May 28, there being apparently no abatement of the rains, as shown by reports from scattered localities over this district, a positive warning was issued and sent to all points between St. Joseph and Boonville, advising that all interests affected by high water should be closely guarded.

Another warning was sent on May 29 to the same places, stating that the situation at Kansas City had become serious; that the uncertainty of the rain outlook placed the river changes beyond accurate calculation, and advised all to be prepared for emergencies.

It was given out locally that the flood would be more serious than that of 1881, a flood very well remembered in this community.

Still another warning was issued on May 30 and sent to points below Kansas City, stating that the stage at Kansas City was but slightly below the flood stage of 1881, which, with heavy rains over Kansas and Missouri, rendered the situation more alarming for points below Kansas City. The stage of the river at Kansas City at 7 a. m. that morning was 25 feet, 4 feet above the danger line.

These were the most definite warnings that could be issued, as there was not one available river gage in the Kaw basin. A destructive flood was anticipated and strong and positive warnings were issued, but an estimate of the height the flood would attain was absolutely out of the question. A number of persons below Kansas City who inquired by telegraph and telephone for advice, have since informed this office that many lives and much property had been saved by the information given them.

Circular letters addressed to postmasters and others at various points along the Missouri River between Leavenworth and Boonville, elicited the replies that warnings of a big flood had been received.

At every point along the Kaw and its tributaries to which a letter of inquiry was addressed a warning had been received in some form, but that the flood would reach such an extraordinary stage was not anticipated by any one.

An estimate of the damage along the various rivers, made up from a great number of reports received, results as follows:

Big Blue River.—(Not including Manhattan at its junction with the Kaw).—Damage to farms, fences, live stock, bridges, and business property, at least \$750,000. At Blue Rapids the river made a new channel, leaving mills and factories far removed from their sources of power, the river having been dammed at that place for the purpose of furnishing power.

Republican River.—(Not including Junction City, where it empties into the Kaw).—Damage began a little west of Superior, and from there to its mouth the general loss is placed at \$600,000, which includes \$12,000 damage to bridges. Lives lost, 3.

Solomon River.—Damage began in Osborne County, of trifling nature at first, but the inundated area increased quite rapidly until it was 5 miles wide for more than 40 miles above its junction with the Smoky Hill River at Solomon. The general damage to lands, stocks, fences, and barns is placed at \$800,000.

Smoky Hill River.—(Including the Saline tributary).—Damage began in Ellsworth County and was particularly heavy from Salina to Junction City, where the Smoky Hill River unites with the Republican River to form the Kaw. Many of the towns and villages were inundated, and about 30 bridges were damaged. In some cases the damage was partial, in others complete.

The general damage to farms, fences, barns, etc., amounted to \$1,400,000; to bridges, \$20,000; to stock, \$23,000; lives lost, 3. In addition to this, heavy losses to commercial and business interests were sustained.

Kansas (or Kaw) River.—The overflowed area was from 2 to 5 miles in width

along its entire length, not including the cities at its mouth. Damage to farms, fences, crops, barns, etc., \$3,000,000; 11,000 acres of rich potato land overflowed between Kansas City and Lawrence, washing out the entire crop and leaving the land practically valueless for farming purposes because of a deposit of sand and silt from 1 to 3 feet deep in places. Damage estimated at \$500,000. Damages to bridges at Junction City, \$250,000; Manhattan, \$100,000; Wamego, \$16,000; Lawrence, \$50,000; Desoto, \$17,500; St. Marys, \$10,000. Others, \$75,000. Local damage at Lawrence, \$300,000; St. Marys, \$50,000; Manhattan, \$25,000; Junction City, \$30,000.

Approximate loss of live stock, \$100,000. Loss of life, 11 persons.

Missouri River.—(Above Kansas City).—There was, comparatively speaking, but little damage along the Missouri River north of Kansas City. At St. Joseph there was an overflow of about 1,000 acres, in what are known as the French Bottoms; damage about \$5,000. No damage to bridges or the city. From that to Atchison only low bottoms were inundated with slight loss. At Leavenworth the Government farm and Kickapoo Island, north of the town, were inundated, and also about 6,000 acres opposite, in Platte County, running chiefly south. All crops were destroyed, and the damage was placed at about \$30,000, not including a considerable number of hogs and a few small bridges. No loss to city or business. From that point southward to Kansas City the flood extended to the higher bottoms here and there.

The total damage north of Kansas City did not probably exceed \$200,000.

Below Kansas City the waters extended from bluff to bluff, being in some places 2 and at others 6 miles wide. The destruction was quite complete and extensive at many places. A general estimate places the damage to farms, fences, barns, etc., at \$1,500,000, and to stock interests, \$17,000. At Liberty the damage is estimated at \$20,000; at Lexington, \$250,000, stock, \$5,000; at Napoleon, \$80,000, stock, \$2,000; at Waverly, \$100,000, stock, \$5,000; at Boonville, \$230,000, stock, \$5,000. These figures do not refer particularly to the places named, but rather cover the damage that occurred within several miles of them. Only small county bridges were washed out between Kansas City and Boonville, the value of which, separately considered, was comparatively inconsequential, though it will require thousands of dollars to replace them. There remain to be mentioned Kansas City, Mo., and Kansas City, Kans., which are situated at the confluence of the Kansas and Missouri rivers. Each river has its bluffs, widening out here and there into low flat bottom lands.

The Kansas River, after coursing eastward almost to the State line, makes a horse-shoe bend about 3 miles from its mouth and flows northward, meeting the Missouri coming from the north about half a mile beyond the extreme northwest corner of Kansas City, Mo. At this juncture the Missouri makes a sharp curve to the east, then east by northeast. It will be seen that they meet in almost direct opposition, and the meeting occurs about three-quarters of a mile above the gage on the Hannibal Bridge. The main portions of Kansas City, Mo., and Kansas City, Kans., are located on hills or bluffs. Kansas City, Mo., extends to the State line, and lies south of the Missouri. Kansas City, Kans., lies north of the horseshoe bend of the Kaw and extends some distance along the west side of the Missouri.

Along each river are low bottoms which, in places, cover considerable areas. In these bottoms are located the great industrial institutions that make Kansas City, Mo., the commercial center she is to-day. In what are called the West Bottoms, from the



Junction City, Kans., looking east from court-house.

junction of the rivers, extending back 3 miles along the Kaw, are located wholesale houses, factories, warehouses, mills, the great packing plants, stock yards, railroad shops and yards, and union depot. Extending along the Missouri River on the south for a distance of 3 miles is a strip of bottom land half a mile to a mile in width, called the East, but which are more properly the North Bottoms. In these bottoms are located Heim's Brewery, with all its necessary adjuncts, Dickey's Tile and Brick Yard, Electric Park, a big glass factory, a paper mill, train yards, etc. Considerable truck gardening is also carried on there.

Directly north of Kansas City, Mo., on the opposite side of the river, is the village of Harlem, on low bottoms that extend back about 2 miles to the north bluffs.

Armourdale is the southern addition of Kansas City, Kans., and lies within the horseshoe bend of the Kaw on very low ground. Directly opposite, on a strip of bottom land half a mile wide by $1\frac{1}{4}$ miles long, and on the south bank of the Kaw, is Argentine.

It will be seen from this description that vast interests and properties of every character are at the mercy of each great flood. There are no dikes or levees to afford protection. It is true that some protective measures have been taken from time to time to guard large interests from loss by floods and to afford protection from such overflows as had been experienced previous to the flood under consideration, but only in a very small way.

The river at this place began a steady rise on May 21. It reached the danger line of 21 feet in the early morning of May 28, and on the next day it was 2.3 feet above. Water was flowing through the streets of Argentine and Armourdale, and many families were driven from their homes; merchants in the West Bottoms were seriously inconvenienced by water in cellars; sewers were stopped; stock yards and packing houses seriously menaced; train service crippled, and bridges endangered.

On the morning of May 30 the river was at 25 feet and rising rapidly. Business generally demoralized; in fact it came to a standstill; everything closed in the bottoms; no train service west; telegraph and telephone service crippled except eastward.

On May 31 the stage of water was 27.5 feet and still increasing rapidly. Toward night the flood extended from bluff to bluff. Armourdale, Argentine, and Harlem had been abandoned, except by those who were unable to make their escape before being surrounded by water. Twenty thousand people had been made homeless, and all the horrors and dangers of a terrible flood confronted the community. All public utilities except the gas company had been put out of service; 16 out of the 17 bridges over the Kaw River went down, the one remaining, that of the Missouri Pacific Railway, having been saved by the weight of 15 large engines with which it was loaded. Every effort was bent to rescue those in danger and to care for the sufferers.

On June 1 the stage was 35 feet, a rise of 7.5 feet in twenty-four hours, and within 2 feet of the 1844 stage. The Missouri and Kansas were no longer rivers; they had merged into an inland sea, confined only by the distant bluffs of the Missouri and the lesser hills lining the Kaw. The ruin wrought furnishes the saddest chapter in the history of the two cities, Kansas City, Mo., and Kansas City, Kans. Scenes of distress and disaster beggar description. The flood swept down with merciless impartiality, destroying alike the belongings of the humble squatter and those of the wealthy corporation.

Houses in Argentine, Armourdale, Harlem, and the East Bottoms were 8 to 12

feet under water. The streets in the West Bottoms had 8 to 12 feet of water in them. Around the union depot the water was 8 feet deep. The north approach to the Hannibal Bridge was carried away, also 200 or 300 yards of the south approach to the Milwaukee Bridge, about 3 miles down the river. There was only one railroad track out of the city. The gas plant was compelled to shut down and the city was without light, water, or street cars, and only the poorest possible facilities for telegraphing or telephoning. At night the city appeared like one deserted, with only the faint glimmer of a candle or kerosene lamp here and there to be seen. Stores of food and clothing had been lapped up and carried away by the seething currents, while hungry and shivering thousands sought relief at the hands of a generous community. Many people, imprisoned in the flooded area, were compelled to witness unending scenes of terror and destruction.

On June 8 the land again appeared in the West Bottoms and the work of restoration began. A trip through these bottoms after the waters had subsided to a normal stage revealed a condition of general ruin and desolation that filled the beholder with utter amazement. Holes in some places 30 feet deep had been gouged in the streets; railroad tracks torn to pieces; great oil tanks, 35 to 50 feet in diameter, and 25 to 30 feet in height, made of boiler iron, had been torn from their moorings and tossed about like frail shanties, some of them being carried miles from their original locations, while others were crushed against bridge piers and destroyed almost beyond recognition; ordinary houses were mere playthings; freight cars were smashed into small pieces and many were carried down the river; heavy engines had been rolled over and over and were found in mud banks, and mud from 2 to 4 feet in depth covered everything. The ruin was terrible and complete and beyond adequate description.

Armourdale suffered the most; one could not tell where the streets had been located, as what was left of the town was but a mass of indescribable ruins. Argentine village was practically in the same condition. Only about 5 per cent of the residences that remain in the Kaw Bottoms will be habitable. Houses in Harlem and the East Bottoms were not in the way of the strong currents and consequently escaped with less damage. The work of rehabilitation began as soon as land appeared, but the restoration to normal conditions will be a herculean task, tedious and irksome.

The Missouri Pacific yards seemed the playground of the flood; about 3,000 head of cattle and hogs were found there when the ground appeared, and there were piles of debris 40 feet high.

An estimate of the damage in this vicinity is, of course, impossible, owing to its varied character, but the following is believed to be conservative:

Damage to railroad properties and interests.....	\$8,000,000
Damage to residence property.....	1,000,000
Damage to streets and sewers.....	300,000
Damage to street railroads.....	250,000
Aggregate personal losses.....	1,000,000
Loss to packing plants, factories, lumber yards, stores of merchandise.....	4,000,000
Furniture and refitting in wholesale districts.....	1,000,000
Total.....	15,550,000

Lives lost, 19.

The consensus of opinion is that the flood of 1903 did not equal that of 1844. At Boonville it was 2.8 feet lower. At Lexington it was at least 2 or 3 feet lower. At Kansas City it was 2 feet lower. At Lisbon it was probably about equal to that of 1844.

Waverly reports that the 1903 flood was 2.8 feet higher than the flood of 1881, and about 2 feet higher than the 1844 stage—evidently an error, for if it were only 2.8 feet higher than the 1881 flood, it certainly must have been lower than the 1844 stage, for the latter was nearly 9 feet higher at this place than the flood of 1881.

Napoleon and Liberty report that it was worse than the 1844 flood, but their statements are indefinite. It is conceded that at some places the flood level may have exceeded that of the flood of 1844, due to the character of bridges at those places, and also to a possible change in the configuration of the river channel, or to some land improvements abutting the river, which would tend to restrict the current, narrow the channel, or otherwise act as a barrier to the free passage of the water. Naturally under those circumstances the level would be unduly raised. Taking Kansas City, Boonville, and Lexington, the perfect harmony shown in the differences between the two great floods fully authenticates the records for future reference. At all places north of Kansas City opinions were unanimous that the flood of 1844 was higher than that of 1903. This flood is regarded as the highest known in the Kansas River.

At Lawrence there are no positive data regarding the flood of 1844. At Manhattan opinions differ. At Junction City old settlers say it was lower than that of 1903, but no exact information was obtainable, as but little attention had been given to the records for 1844. A really accurate comparison can not be made, but it appears to be the consensus of intelligent opinion that the flood of 1903 in the Kansas River Valley was the greatest ever known.

The river at Kansas City rose steadily from 12.9 feet, May 20, until June 1, when it reached the climax, 35 feet exactly. It fluctuated slightly below that level during the day, under the influence of the subsiding Kaw, which began to fall early in the day, but a wave in the Missouri a little more than counterbalanced the fall in the Kansas and brought the water back to the original height by 6 a. m. of June 2, where it remained until about 6 p. m. of that date, after which the fall of the Kaw more than equaled the supply of the Missouri, and, as a result, a fall of 0.6 of a foot was shown at 6 a. m. June 3, on the Missouri gage.

The crest of the Kaw flood moved at the rate of 2.6 miles per hour, as near as could be determined, and reached Kansas City at 6 a. m. June 1, but the unwavering stage on June 2 at Kansas City, due to the action above explained, should be the determining factor in considering the crest movement in the Missouri. It should be timed from Kansas City at 6 a. m. June 2, reaching Lexington 61 miles east at 6 a. m. June 3, and Boonville about 9 p. m. June 5, which gives the crest movement a rate of 2.2 miles per hour between Kansas City and Boonville, 189 miles below.

It is generally conceded by engineers that the multiplication and character of bridges within 3 miles of the mouth of the Kaw, together with encroachments on the normal channel of both the Kaw and Missouri by filling in and reclaiming, raised the flood level here 4 or 5 feet above what it would otherwise have been. These encroachments and the obstructions offered by bridges, in addition to the congested condition of the wholesale and manufacturing districts, greatly retarded the discharge of the Kaw River. This was plainly shown in the height attained in different places from 1 to 3 miles above the mouth of the Kaw. The water was halfway or more on the engines that weighted down the Missouri Pacific bridge; at that level they, with the floor and debris caught by the framework of the bridge, formed a dam of considerable length; as

a result the current changed and swept furiously around the west end of the bridge, cutting its way, and leaving its worst marks of destruction in that locality.

The natural width of the Kaw channel is 900 feet, but at many places within 3 miles of its mouth it has been narrowed to between 500 and 600 feet; and one bridge was not much more than 400 feet in length. The velocity of the current was 12 miles an hour in many of the streets in the West Bottoms, having been accelerated by the damming up, as well as by the irregularity of buildings and other obstructions.

The velocity of the current at the time of the maximum flood stage under the Hannibal and St. Joseph railroad bridge was about 8 miles an hour. It should also be stated that the width of the Missouri from some little distance above the Hannibal Bridge to a considerable distance below, has been greatly narrowed in recent years by encroachments on either side, especially on the south side, by filling in, reclaiming, etc., so that instead of a 2,000-foot channel, or more, it now measures exactly 1,120 feet from bank to bank where overflow begins.

Considerable discussion has been had since the flood regarding the best method for future protection from Kaw overflows, but without practical results. The most attractive theory is to dike the Kaw for about $3\frac{1}{2}$ miles, but this theory may be impracticable unless commercial interests are willing to give up land that originally belonged to the Kaw channel.

From the bluffs at the union depot to Riverview (on Kansas City, Kans., side) is $1\frac{1}{3}$ miles. Over this entire bottom the water averaged 8 feet in depth, which, consid-

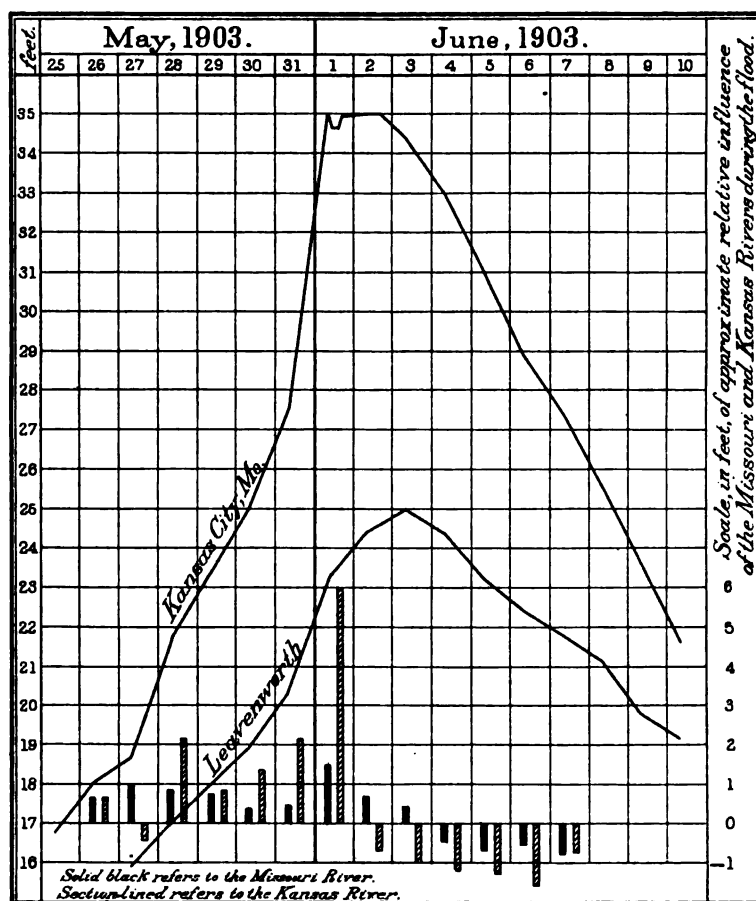
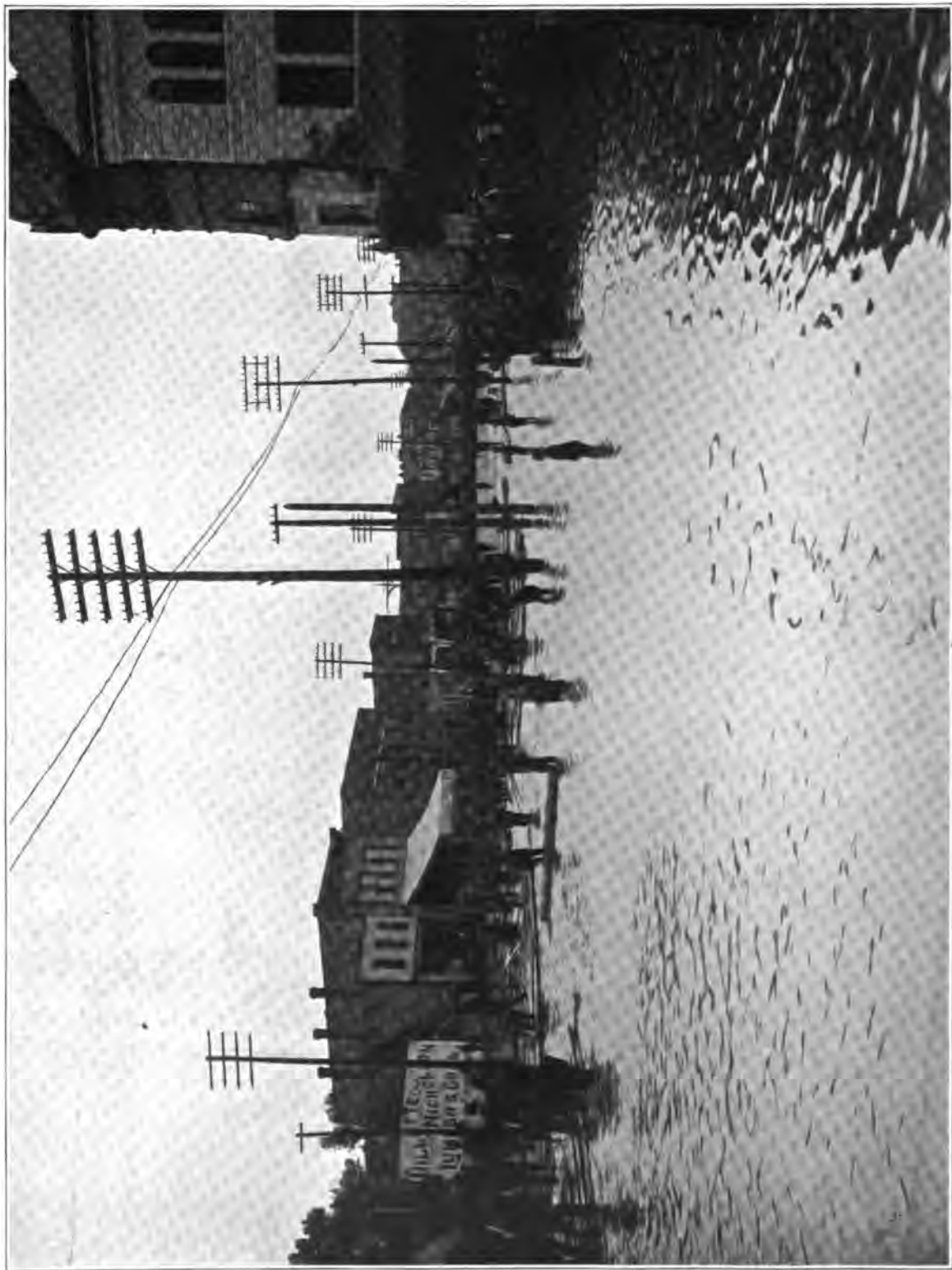


FIG. 3.—Rise and fall of the Missouri River at Kansas City, Mo., and Leavenworth, Kans.



Topeka, Kans. Building pontoon bridge from Rock Island Depot to south approach of Melan Bridge.

ering the natural channel at 500 feet, would require dikes of prohibitive height. Hence, unless abutting land is given up to widen the channel to 900 or 1,000 feet, diking would appear to be practically impossible.

A diagram, fig. 3, accompanies this report showing the rise and fall of the Missouri River at Kansas City and Leavenworth during the flood (the Kansas City curve including the Kaw River supply); it also shows the approximate relative influence, daily, of the Missouri and Kaw rivers in causing the flood.

Kansas River at Topeka, Kans., and vicinity, by Mr. T. B. Jennings, Section Director, Topeka, Kans.—Kansas has an average fall of 2,145 feet from the west to the east line of the State, and an average fall of 355 feet from the north to the south line.

The principal river in the northern half of the State finds its source in the extreme eastern part of Colorado and western portion of Kansas, and flows eastward across the State into the Missouri River at Kansas City. This river is called the "Smoky Hill" from its source to its junction with the Republican at Junction City in Geary County; but from Junction City to its mouth at Kansas City its geographical name is the Kansas River, though it is popularly dominated the Kaw. The waters in the far northwest counties flow northeastward and discharge into the Republican River in Nebraska; the latter river flowing eastward enters Kansas at the northwest corner of Republic County, then flowing southeastward it joins the Smoky Hill in Geary County to form the Kansas.

The distance in miles and fall in feet between prominent river points are given in the following table:

Distance by river from—	To—	Miles.	Fall in feet.	Feet per mile.
Republican City	Republic	90	444	4.9
Republic	Junction City	100	417	4.2
Salina	Junction City	50	146	2.9
Junction City	Manhattan	24	66	2.8
Hanover	Manhattan	70	213	3.0
Manhattan	Topeka	60	132	2.2
Topeka	Kansas City	75	151	2.0

The bed and banks of the river are a very compact sand. The banks of the Kaw are from 15 to 30 feet high. Its bluffs are usually found in close proximity on the south, while the valley generally spreads away northward. The bed of the river varies between 80 and 160 rods in width, but at Topeka, where the bridges cross, it is narrower than usual, and was still further narrowed when building the Rock Island and Melan (Kansas avenue) bridges by making "fills" for approaches instead of spans or arches. Its watershed extends from 10 to 20 miles south of the river northward to the southern counties of Nebraska, including all of this State north of the river except the counties of Brown, Doniphan, and Atchison.

The flood of May 28 to June 3, 1903, was the most disastrous since the settlement of the valley, and was the direct result of the excessive rainfall in the central and northern counties of this State and the southern counties of Nebraska.

Within the area of excessive precipitation the rainfall for the first nineteen days of May averaged 4.04 inches; during the nine days from May 20 to 28 inclusive, it averaged 4.49 inches; on May 29, 2.43 inches; on May 30, 0.45 of an inch, and on May 31, 0.33 of an inch. By May 26 every stream was bank full and many were overflow-

ing. Then came the great rains of May 28 in the central group of counties, culminating in 5.25 inches at Salina, and an estimated fall of 15 inches at Abilene (where the rain gage was washed away). This volume of water was thrown into the Kansas River and from Manhattan but one bridge (at Wamego) was left across the Kaw until the Rock Island bridge at Topeka was reached. By noon of May 28 the river at Topeka had reached 16 feet; Friday morning, May 29, it was 19 feet; during Friday night it rose rapidly, and continued rising all of Saturday, May 30, reaching its maximum, or crest stage of 27 feet, about 9 o'clock that evening. It receded very slowly, however, being still some 23 feet deep Tuesday evening, June 2.

On Saturday, May 30, the water tore out the street car bridge which was built on piles just west of the Kansas Avenue (Melan) Bridge, and by 4 a. m. of the next day had washed out the north and the east side of the approaches to the latter bridge, both the work of return currents. The weight of opinion indicates that the narrowing of the river bed in building the Rock Island and Melan bridges threw the water into north Topeka earlier than it would otherwise have come, but made little if any difference in the final outcome. The debris brought down by the river lodged in the trestle-work of the Rock Island bridge after the water had risen to the bridge floor, and acted as a dam, raising the water 2 feet higher on the west side of the bridge than on the east. The water tore up the asphalt pavement on Kansas avenue just north of the bridge and left it in Mr. Skinner's yard on the east side of the avenue.

When the water reached the lime houses the slacking lime started a fire that consumed a large quantity of lumber, terrified the citizens who had taken refuge in trees and on the tops of houses, and greatly increased the danger to the rescue boats. At Gabriel's lumber yard a shed, 100 feet in length, and well filled with lumber, both upstairs and down, was carried across the street and landed on the sidewalk without disturbing any of the lumber.

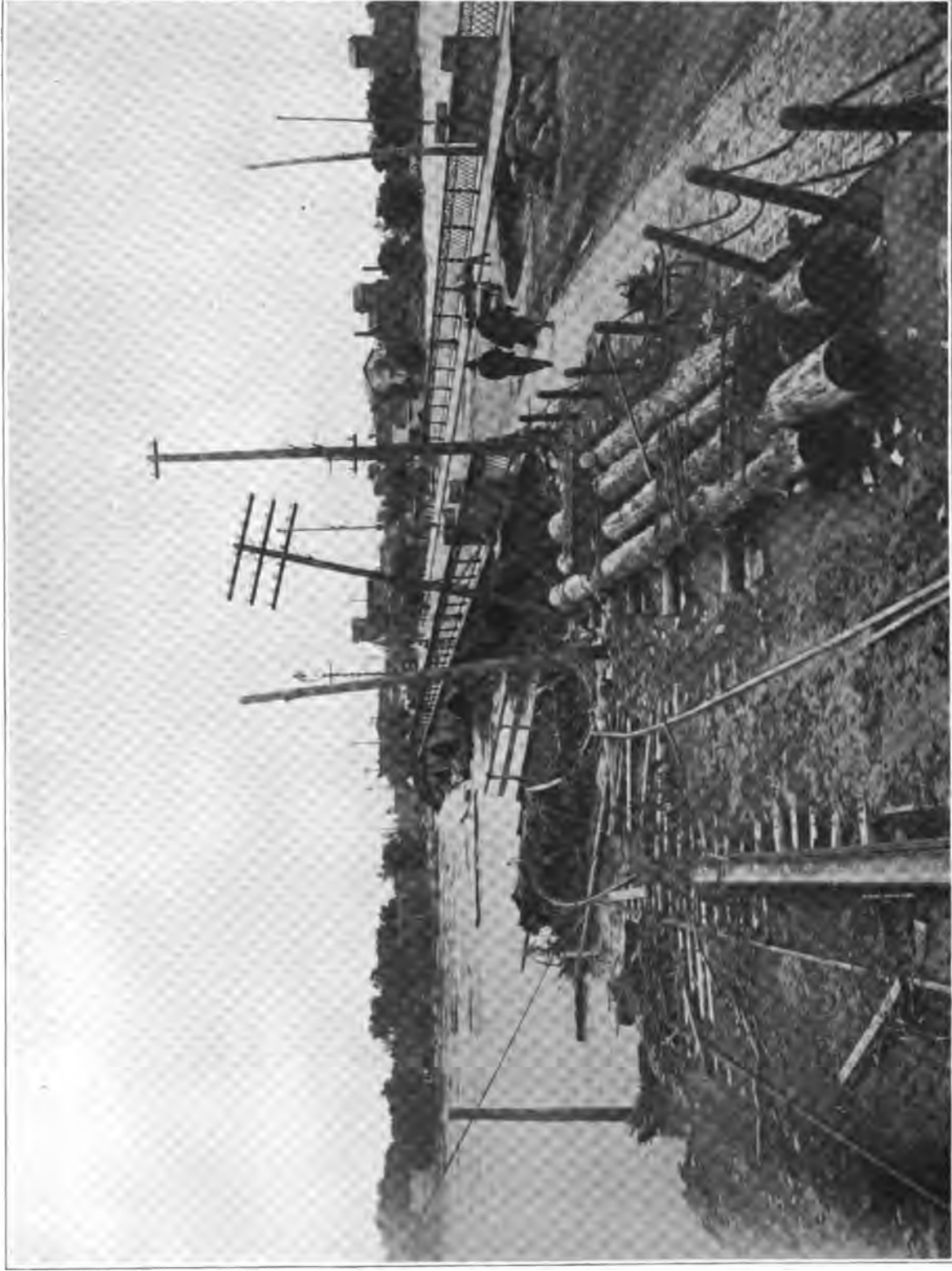
The soil under north Topeka is mostly sand to a considerable depth. This became thoroughly saturated with water, often acting like quicksand, and in places great holes were made by the currents.

As the waters subsided, silt and sand were deposited indoors and out alike, being 18 inches to 2 feet in depth indoors, and 18 inches to 3 feet deep in the yards and streets, completely changing their contour. As one writer tersely said, "Nothing is as it was." The crops on the farms and market gardens were utterly ruined, but as soon as the soil became workable new crops were put in, and market gardeners are at this date (August 1) realizing from their investments. The nursery fields east of north Topeka were covered with sand which buried their crops of young trees, and after the subsidence of the water the fields presented a very bare aspect. At this date, however, they are covered with a growth of young cottonwoods, growing up from seed blown there since the flood-waters subsided.

The city pumping works were flooded and the large water main leading from them was washed out, and the city for four weeks had to depend on the pumping engine of the Atchison, Topeka, and Santa Fe Railway shops for its water supply.

The records show a death list of 38, but it is not believed that this covers the total loss of life.

The loss suffered by the business firms on north Kansas avenue, in their stocks, amounts to upwards of \$300,000. To this must be added the losses in furniture,



Topeka, Kans. Melan Bridge after water had fallen 6 feet.

libraries, homes, milling stuff, lumber, etc., which caused the total losses to be over \$2,000,000.

Cattle, horses, and hogs floating down the river lodged in north Topeka and afterwards had to be burned.

Mississippi River from below St. Louis, Mo., to Cairo, Ill., by Mr. P. H. Smyth, Observer, Cairo, Ill.—This flood was due to rises out of the Missouri and upper Mississippi and tributaries, and the stage at Cairo was augmented somewhat by rises out of the lower Ohio and its tributaries. Accurate warnings were sent out well in advance of the flood's crest, and consequently very little movable property was lost.

The maximum stage reached at Chester was 33.3 feet on June 13, 3.3 feet above the danger line, and exceeding the flood of May, 1892, by 2.1 feet.

At Cape Girardeau the maximum stage reached was 36.6 feet, exceeding the flood of May, 1892, by 0.9 of a foot.

The flood wrought great destruction in this vicinity, that is, at points on the Mississippi above Cairo. A relief committee sent out by the citizens of Cairo reported as follows:

"The conditions are indescribable. No one can imagine the extent of the destruction and desolation caused by the flood, especially in the vicinity of East Cape Girardeau and McClure. There are fully 30,000 acres of fertile land in this county upon which the crops are a total loss. Water is 2 feet deep in the streets of McClure and is sweeping down from the Union County line to the bluffs at Gale. Almost an entire township in the northwestern portion of the county is inundated. The water is 2 feet higher than the oldest citizen has ever before known it to be, but is 3 feet lower than it was in 1844, as shown by marks on the Sturdevant Bank of Cape Girardeau."

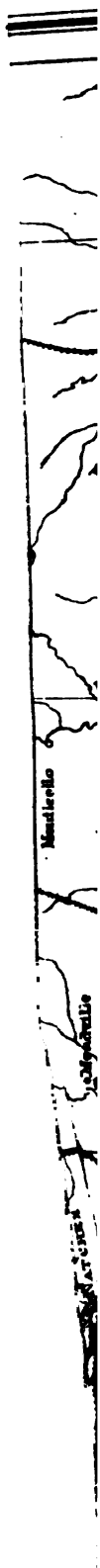
All bottom lands were inundated and all crops thereon reported lost.

The Illinois Central Railroad Company suffered considerable damage between East Cape Girardeau and McClure. Engineers who have made a trip over the road in the districts flooded roughly estimate the damage to the line at \$100,000.

During the progress of the flood numerous inquiries were received at the Cairo office by telegraph, telephone, and mail as to the probable extent of the rise.

The following is an extract from an editorial that appeared in the Cairo Citizen of June 18, 1903:

"The value of the Weather Bureau in this flood period was again demonstrated. On June 2 the Bureau sent out the warning that stages exceeding the danger line were indicated for all points on the Mississippi from St. Louis to above Cairo. On June 5 it was predicted that 42 feet would be reached within four days, and on the following day that the crest would exceed 43 feet. The river came to a stand seven days later at 43.4 feet."



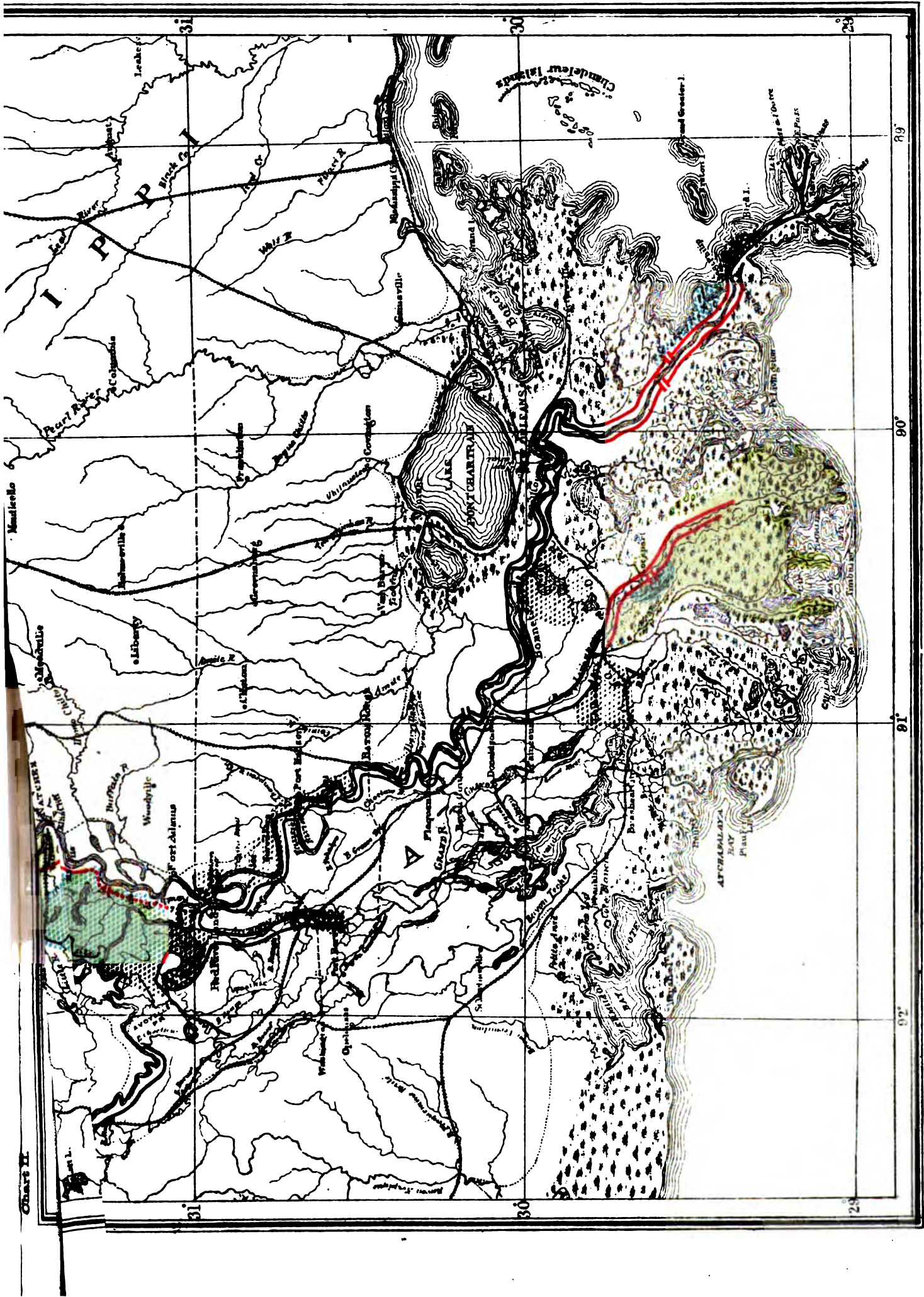


Chart III. Hydrographs for Flood of 1903.

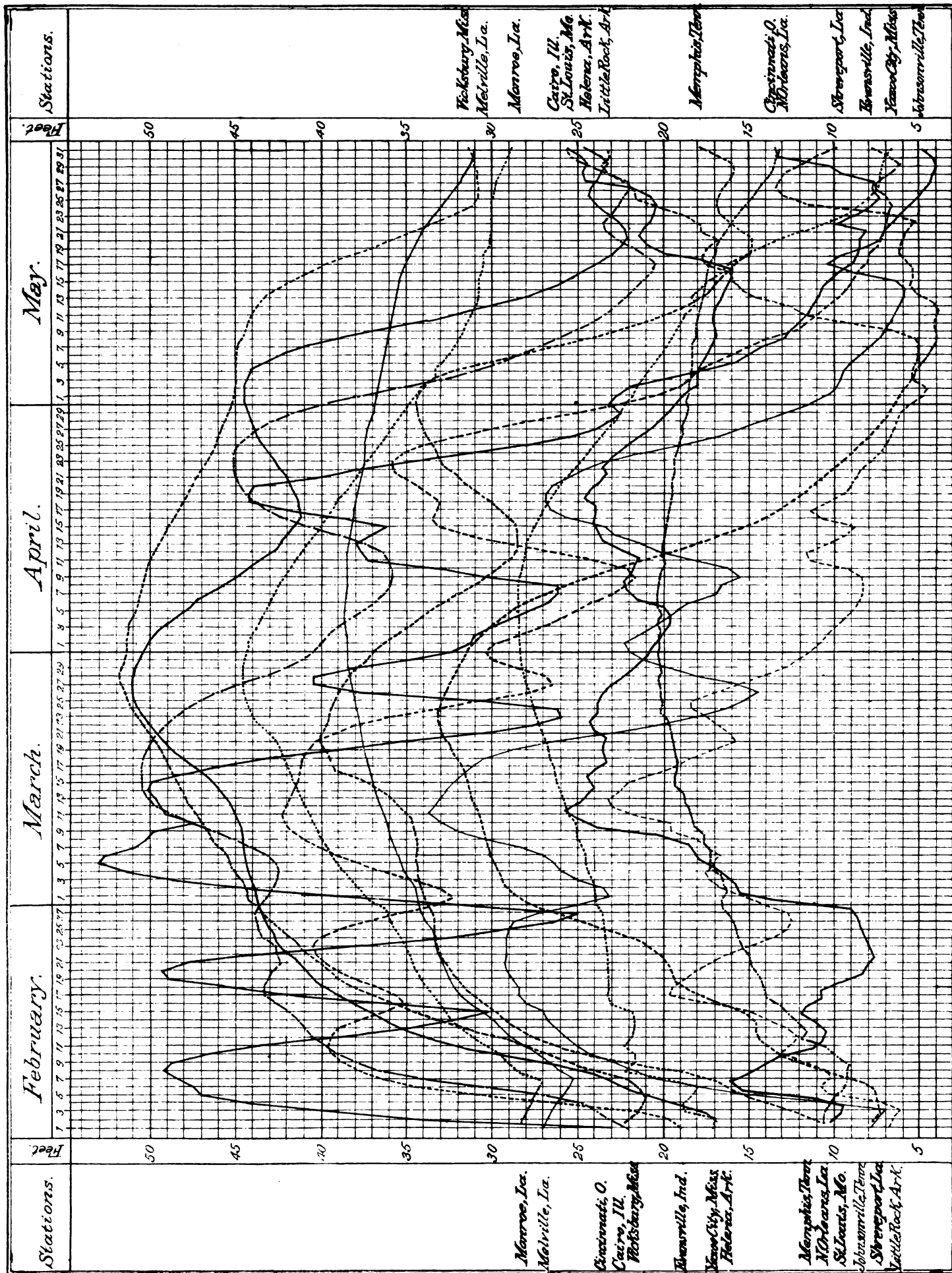


Chart IV. Precipitation for January, 1882.

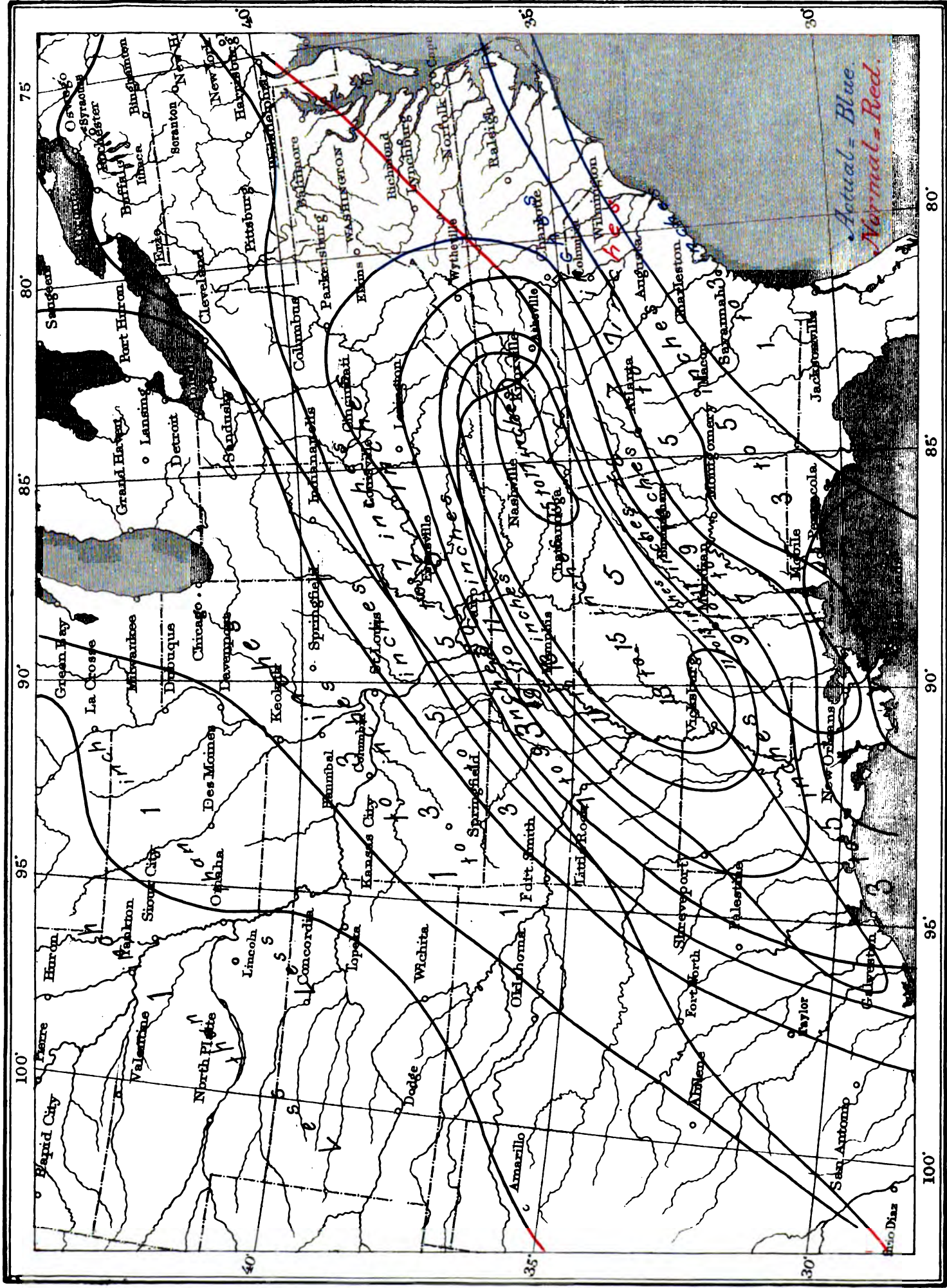


Chart V. Precipitation for February, 1882.

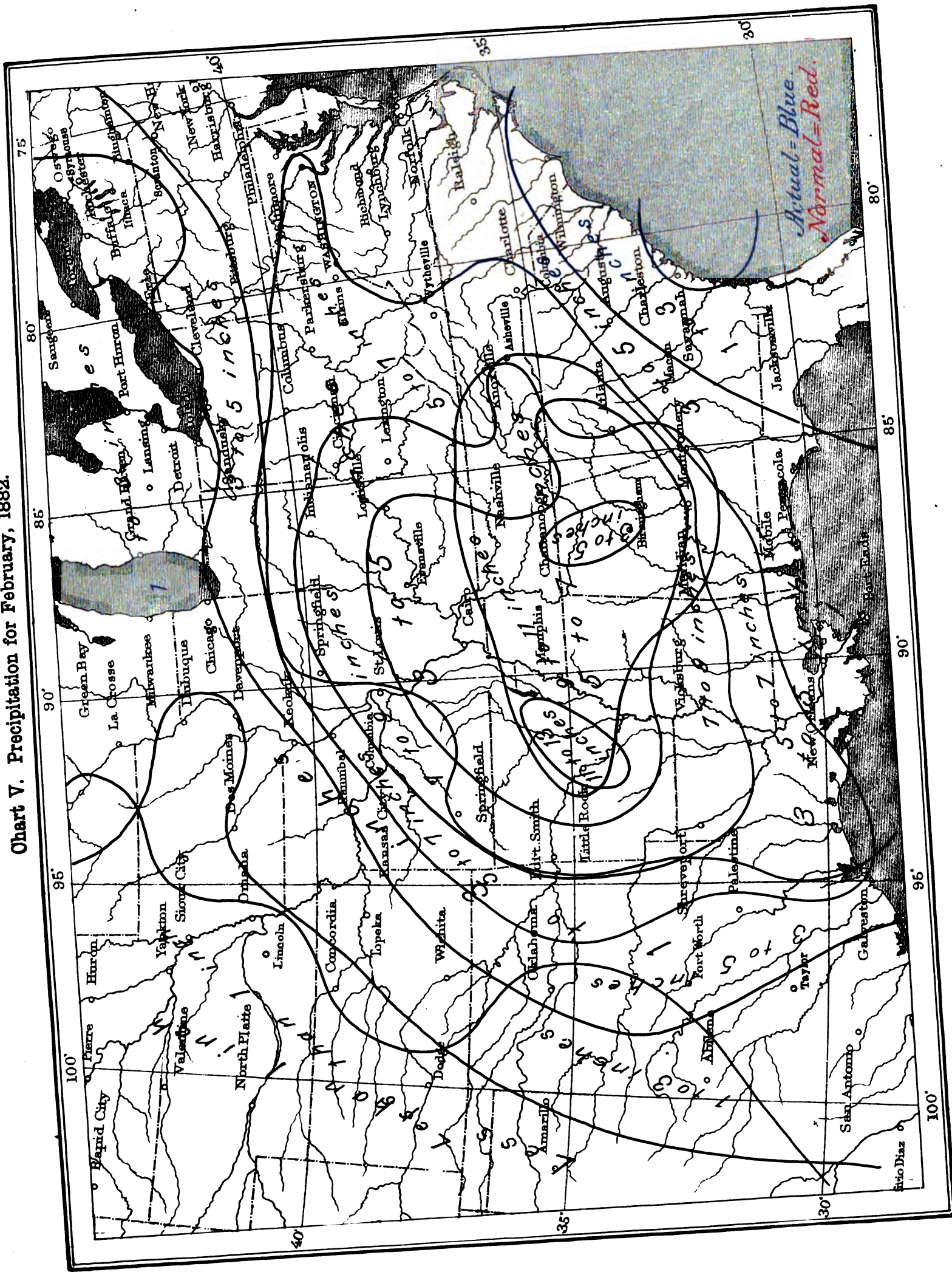


Chart VI. Precipitation for March, 1882.

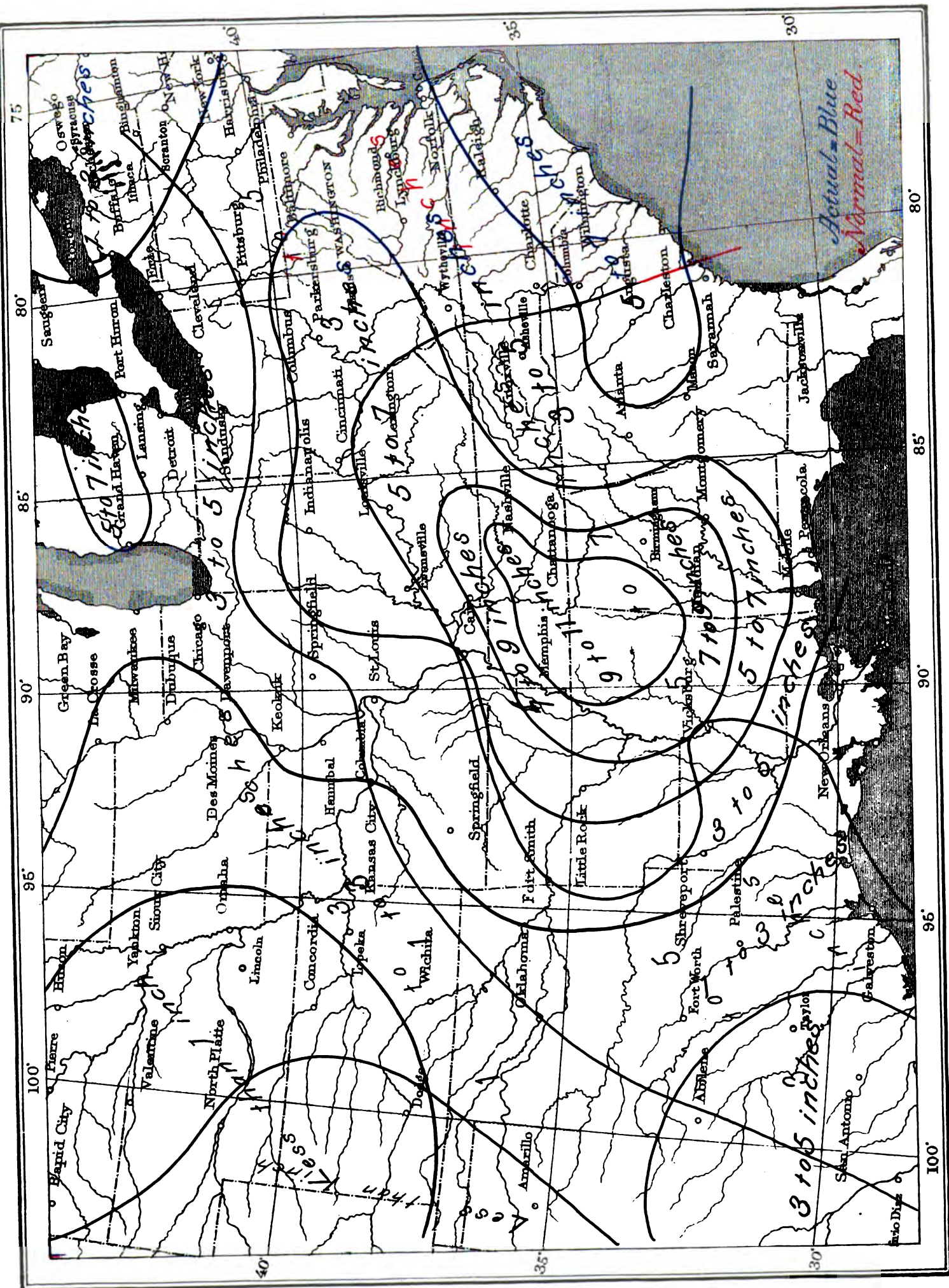


Chart VII. Precipitation for January, 1897.

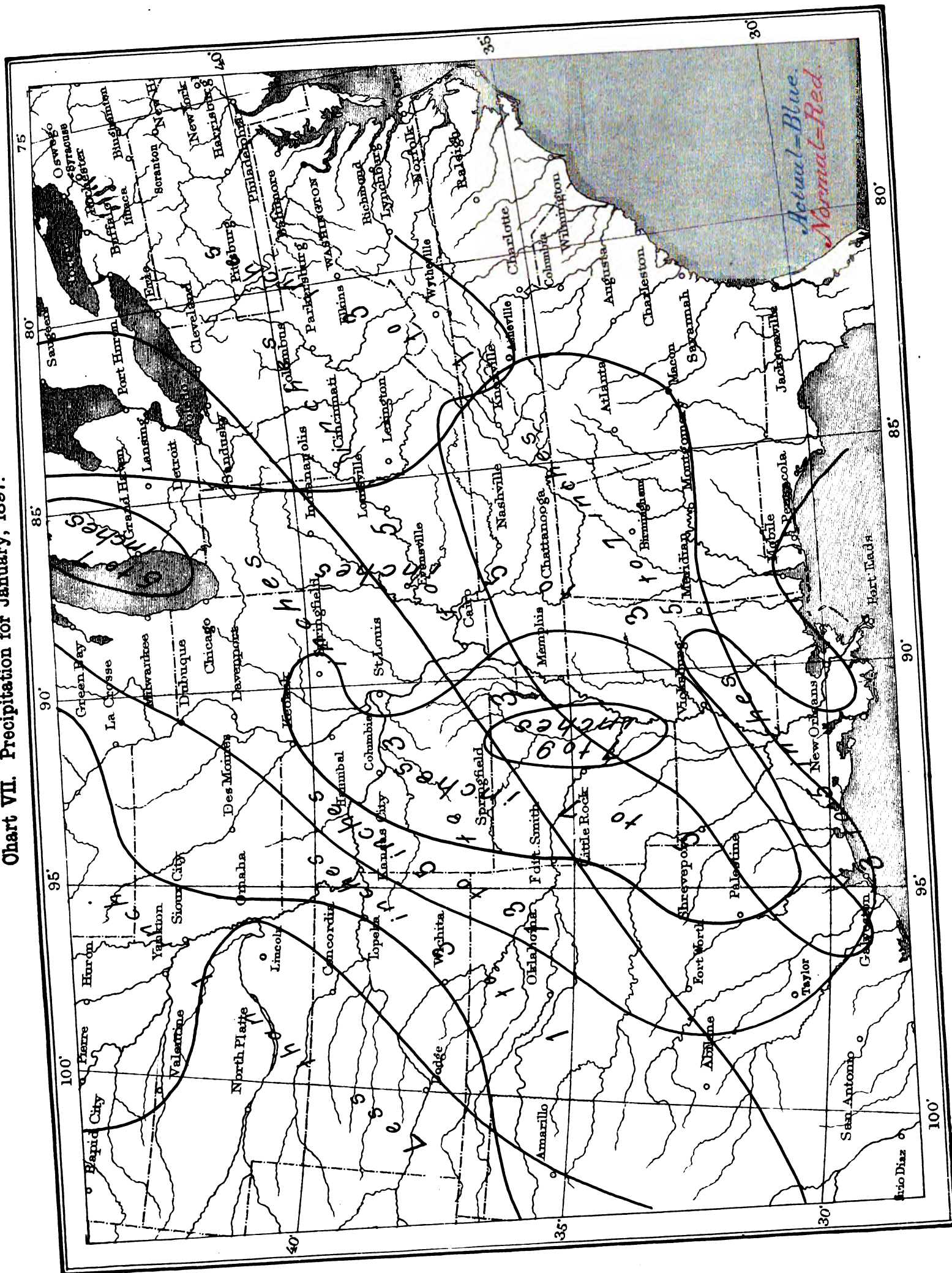


Chart VIII. Precipitation for February, 1897.

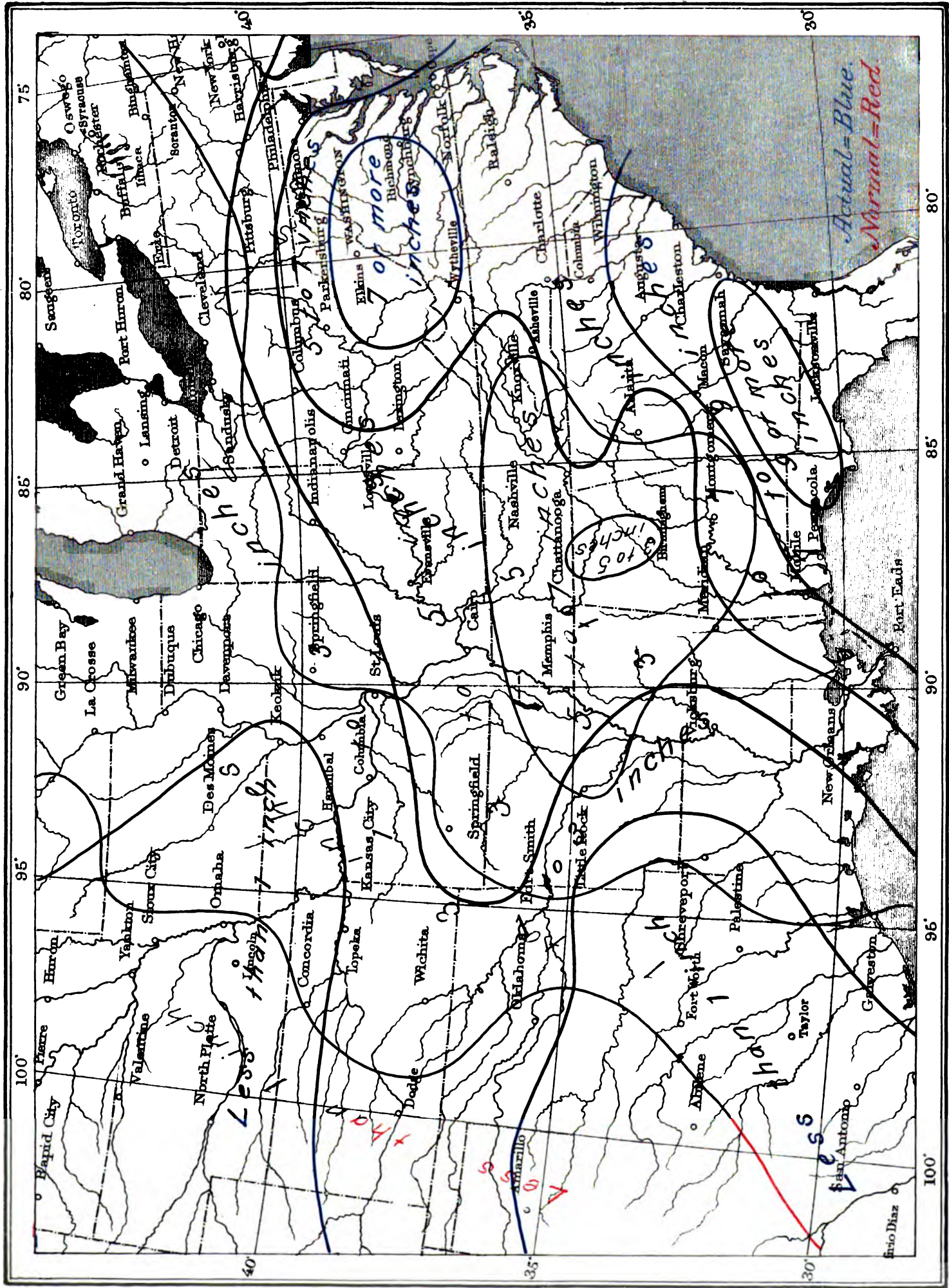


Chart IX. Precipitation for March, 1897.

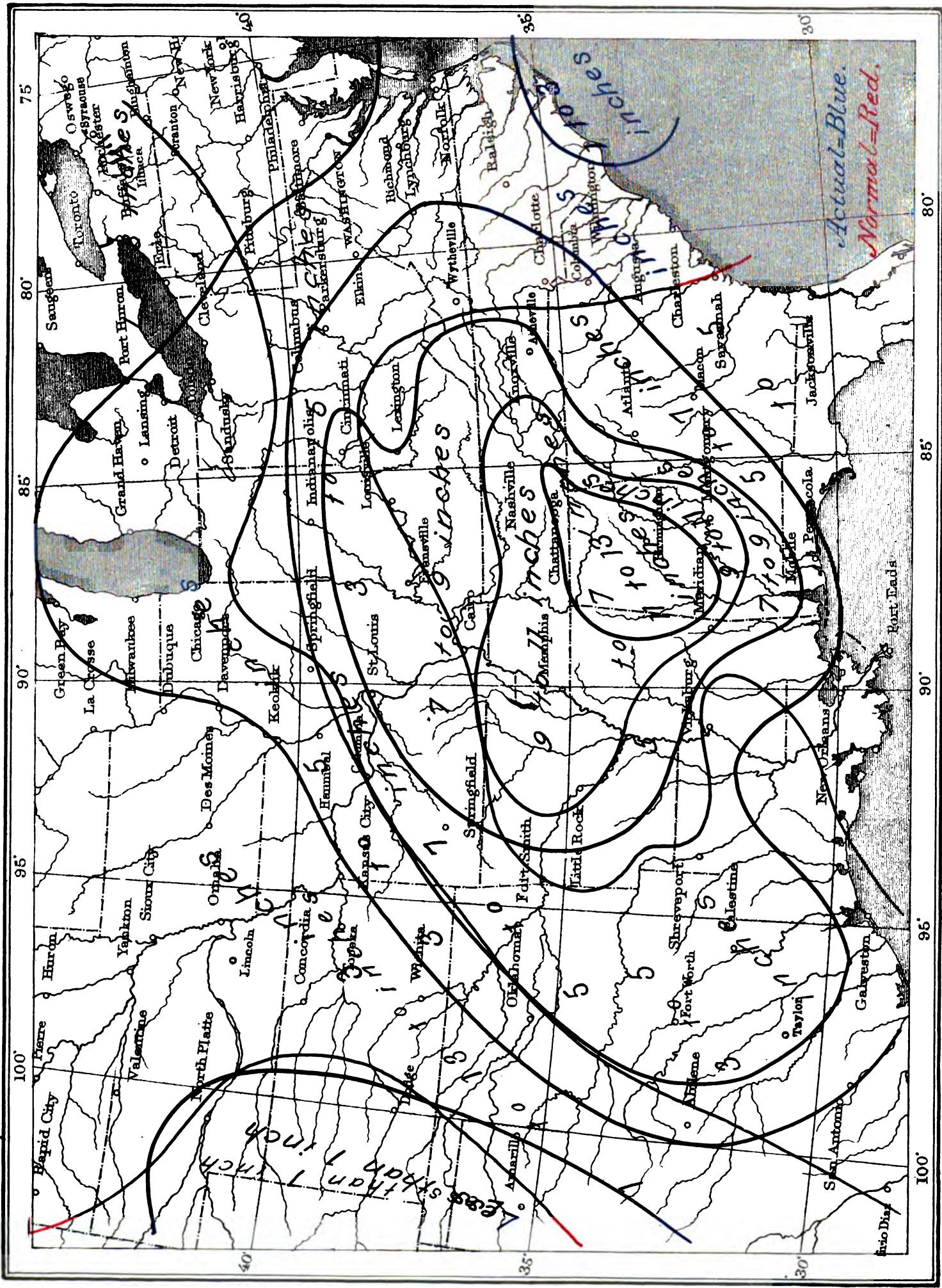


Chart X. Precipitation for January, 1903.

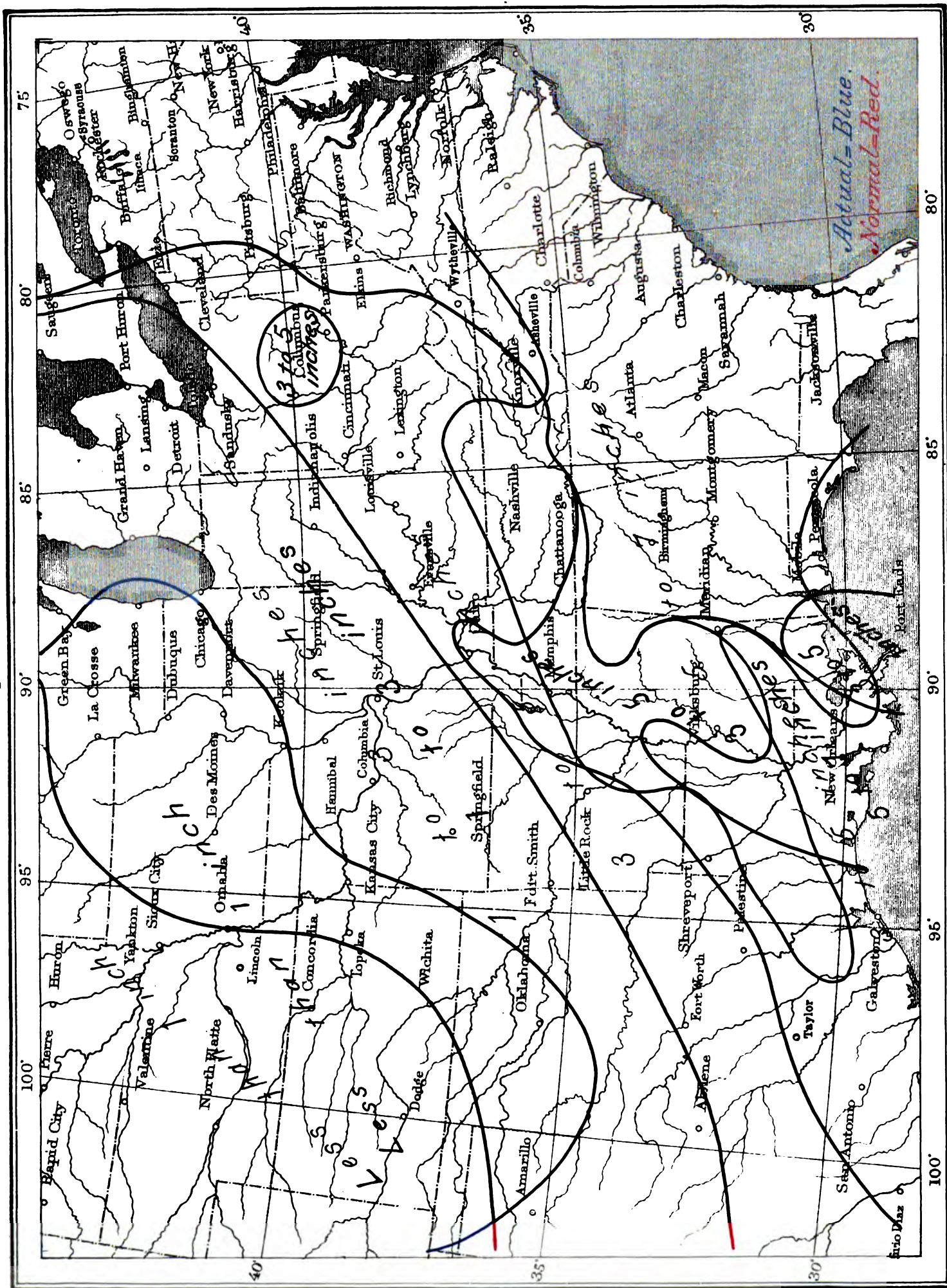


Chart XL. Precipitation for February, 1903.



Chart XII. Precipitation for March, 1903.

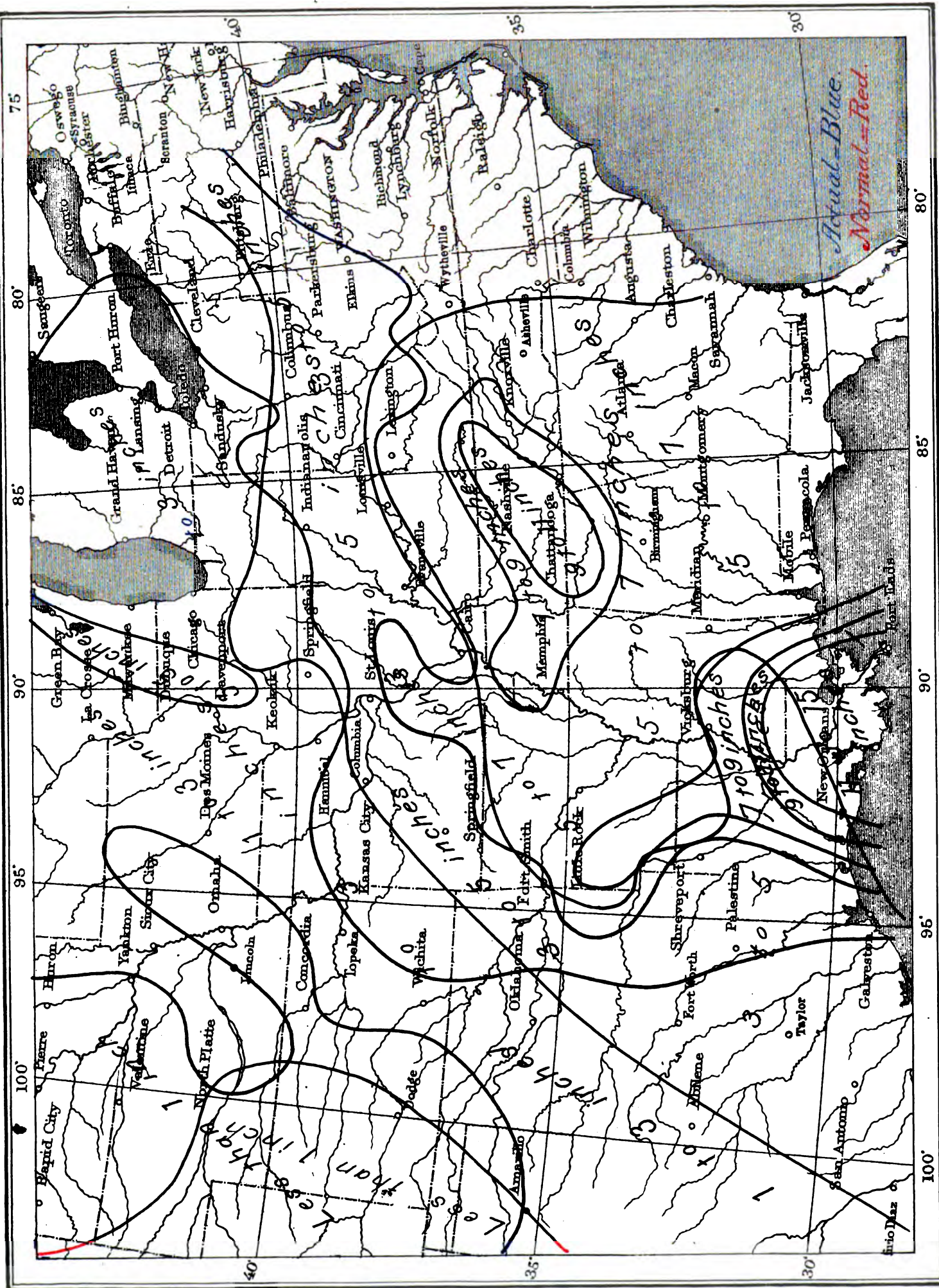


Chart XIV. Hydrographs for Flood of 1903.

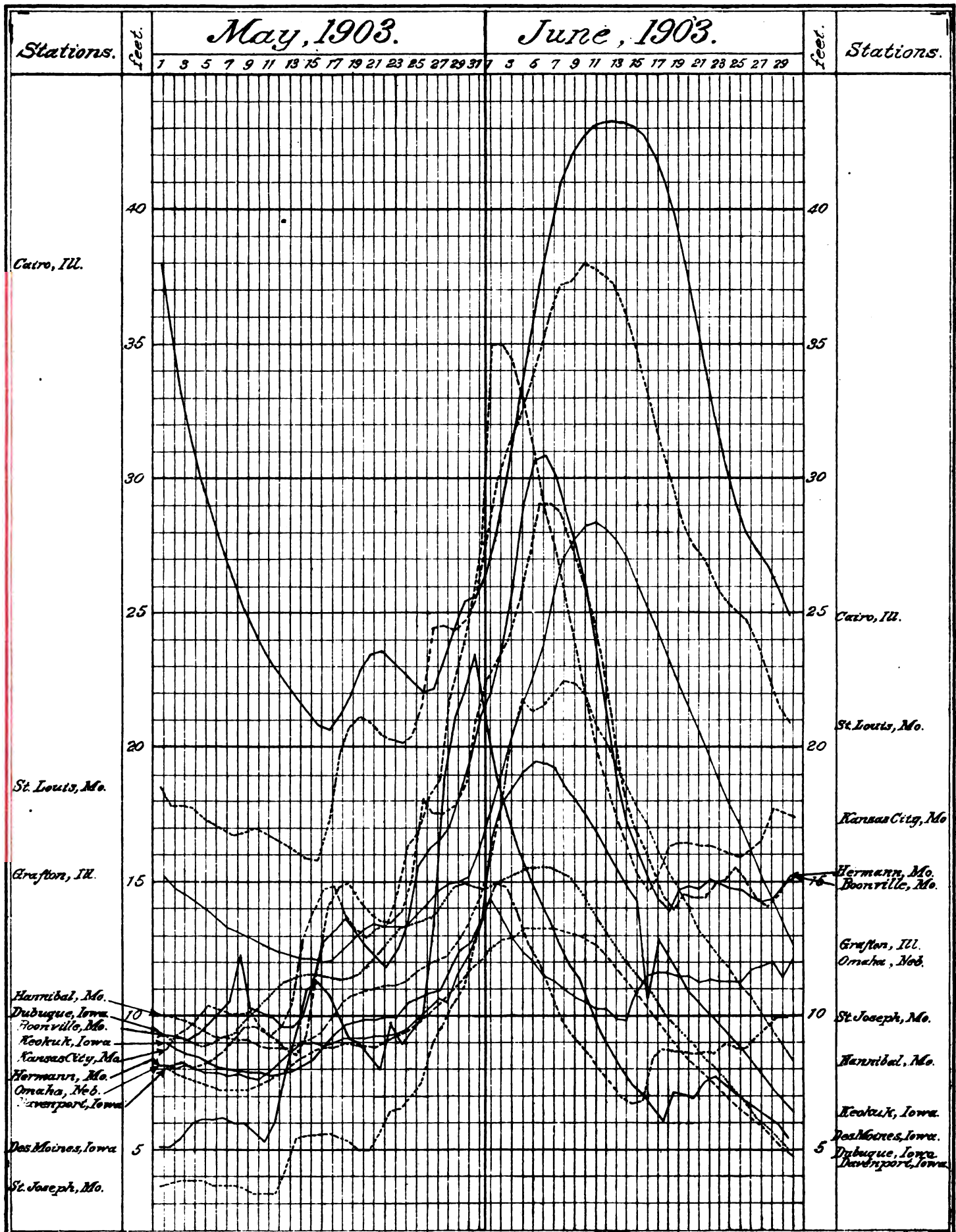


Chart XV. Precipitation for May, 1903.

